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ROENTGEN DIAGNOSIS OF THE STRAWBERRY GALL BLADDER[1]

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A GREAT advance in the diagnosis of gall-bladder disease was made with the advent of cholecystography. The accuracy of this method, as proven by operative findings, is probably not excelled by any other diagnostic procedure. Yet statistics of this sort are necessarily incomplete. No exact check is available on the diagnosis of cases which do not go to operation, and these include, for the greater part, those reported as "negative" or "normal" gall bladders.

[1] Presented before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

Fig. 1. Strawberry gall bladder (×200). *A*, normal villous process, *B*, typical distended villous process containing endothelials laden with cholesterol, *C*, lymphocytic infiltration due to associated mild inflammatory changes.

The strawberry gall bladder, also referred to as cholesterosis or lipoidosis of the gall bladder, is one of the earliest forms of gall-bladder disease. There is still a

Fig. 2. Strawberry gall bladder. The typical case shows a good shadow, due to the fact that sufficient normally functioning mucosa remains to concentrate bile (dye). Good visibility is probably responsible for these cases being reported as "negative" or "normally functioning" gall bladder.

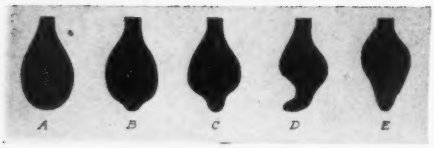
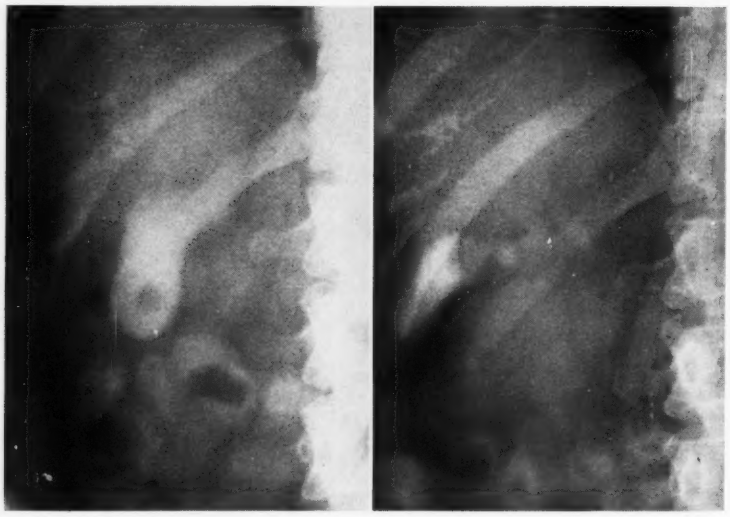


Fig. 3. Roentgenoscopic appearance of gall-bladder contractions. *A*, gall bladder at rest. *B* and *C*, usual types of contraction. *D*, unequal contraction of longitudinal fibers. *E*, vigorous contraction, seen occasionally in strawberry gall bladder with stones.

appearance of a ripe strawberry. There will be small, yellowish specks on a deep red base (Plate I). Microscopically, there is noted infiltration with lymphocytes and plasma cells (Fig. 1). The process may be diffuse or localized to a single area of mucosa.

The symptoms are comparatively mild, but definite. Most patients complain of indigestion, gas, and distress after meals.



A *B*

Fig. 4. Strawberry gall bladder containing single stone. *A*, gall bladder at rest. Note stone at fundus of vesicle which is wide and relaxed. *B*, 15 minutes after ingestion of motor meal. Note tapering of fundus due to vigorous contraction which has forced the stone into the neck of the vesicle, partially occluding the cystic duct.

conflict of opinion as to whether the process is of metabolic or inflammatory origin. In most cases, probably both factors are involved (1, 2). The mucosa and submucosa become edematous and absorption is impaired. The normal process of bile concentration, which is accomplished by absorption of water, bile pigments, and cholesterol, is disturbed, so that only water and bile pigments are taken up. The cholesterol which remains in the vesicle soon reaches a high concentration and precipitates in the form of small particles, deposited mostly on the tips of the villi. If the gall bladder is sectioned at this time and washed free of bile, it will present the

Jaundice and colicky pain are absent, though not infrequently there may be a sallow skin and right upper quadrant or epigastric discomfort. The condition is much more common in women and its onset is frequently in relation to a recent pregnancy. This occurrence suggests an endocrine or metabolic origin. In our series of 30 proven cases, the sex distribution was 3.3 per cent males and 96.7 per cent females.

Roentgen Diagnosis.—Cholecystography, as commonly practised, is not adequate for diagnosis, since a film taken some 14 hours after administration of dye and another taken after a fat meal will, of themselves,

Plate I. Strawberry gall bladder (opened). Precipitated cholesterol is deposited at the tips of the villi. These particles coalesce to form larger masses and stones.

fail to demonstrate the changes which constitute the diagnostic criteria.

It must be remembered that the gall-bladder mucosa is extremely redundant, so that, in spite of disseminated mild involutionary changes, sufficient functioning mucous membrane remains to concentrate bile. Cholecystograms, therefore, usually show a good gall-bladder shadow (Fig. 2).

After the first film has been inspected, the patient is given a motor meal consisting of four egg-yolks (the whites are discarded to diminish bulk) and eight ounces of 40 per cent cream, flavored with ginger

Fig. 5. Examination for reflex tenderness. The left costo-vertebral angle is first palpated to determine the general reaction of patient. Pressure is then applied to the right costo-vertebral angle. Tenderness in the latter region is frequently associated with gall-bladder disease.

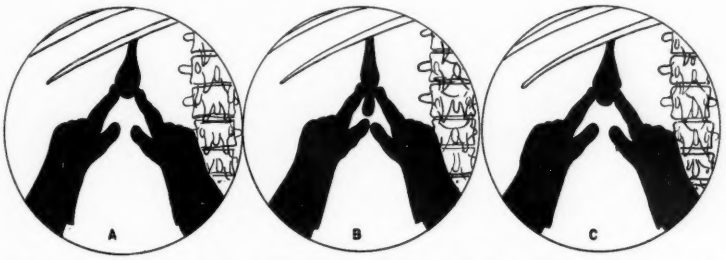


Fig. 6. "Stripping," to determine elasticity of the gall bladder. *A*, the index fingers are placed on the abdominal wall at either side of the fundus of the vesicle and pressure is applied. *B*, during deep inspiration, the gall bladder glides between the fingers as an elongated and narrowed shadow. *C*, in the presence of stones, a constant bulge is seen at the finger-tips.

ale. At the Massachusetts Memorial Hospitals, it has been our practice to examine these patients under the roentgenoscope since the Graham test was first introduced (3). Within ten minutes after the ingestion of the motor meal, the gall bladder is seen to contract. There is a slight tapering of the fundus (4). The contraction wave moves quickly toward the cystic duct, a small jet of bile is expelled, and the gall bladder relaxes. This is soon followed by another contraction cycle, but with each remission to the resting stage, the vesicle becomes smaller due to progressive tonic contraction of the muscle fibers (Fig. 3). Roentgenoscopically, the strawberry gall bladder is seen to be much more active than the normal gall bladder. The greatest activity, however, is seen in the strawberry gall bladder containing one or a few cholesterol stones. This increased activity is not unlike what is observed in the duodenum due to the presence of an active ulcer. It may be well to emphasize that gall-bladder contractions are not of the magnitude of peristaltic waves in the stomach; the gall-bladder musculature is comparatively sparse, so that contraction is manifested by only slight alterations of contour (Figs. 3, 4). This observation is best made with respiration suspended since changes in contour are produced by respiratory motion.

During roentgenoscopic examination, the localization of tenderness is ascertained. Tenderness over the gall bladder is an important element in diagnosis, found in more than 90 per cent of these cases. We find it helpful, also, to examine the right costo-vertebral angle. This sign is best elicited by examination in the prone position with both arms on the table by the

TABLE I.—AVERAGE EMPTYING TIME OF THE GALL BLADDER

Normal	4 hours
Strawberry Gall Bladder	1 hour and 20 minutes
Strawberry Gall Bladder with Stones	4 hours
Chronic Cholecystitis (with or without stones)	Over 5 hours (not followed to complete emptying)

sides. The middle finger and thumb are placed in the left and right costo-vertebral angles, respectively (Fig. 5). Gentle pressure is applied, first to the left, to ascertain the general reaction of the patient, and then to the right. We have found "reflex tenderness" in the right costo-vertebral angle in over 92 per cent of the cases which, at operation, were shown to have gall-bladder disease. It was absent in over 95 per cent of the cases reported as normal (5).

Attention is then directed to a determination of the elasticity of the vesicle. This is best done by placing the gloved index fingers on the abdomen, at either side of the fundus (Figs. 6-*A* and 6-*B*). The patient is instructed to take a deep breath, during which the gall bladder will be seen to glide between the finger-tips as an elongated and narrowed shadow. Since the pathology of the strawberry gall bladder is confined mostly to the mucous membrane, elasticity, as determined by this procedure, is still preserved. On the other hand, in chronic cholecystitis, elasticity is usually impaired or lost. This method, which we have called "stripping," frequently enables us to detect the presence of stones at roentgenoscopic examination. In these cases, there will be a constant bulge of the gall-bladder shadow at the finger-tips (Fig. 6-*C*).

The strawberry gall bladder empties rapidly (6), complete disappearance of its shadow occasionally occurring 30 minutes after ingestion of the motor meal, and most cases will show complete emptying in less than two hours (Figs. 7, 8, and 9). The average emptying time in a series of 20 strawberry gall bladders without stones confirmed at operation, was one hour and 20 minutes (Table I). In the presence of stones, emptying may be delayed due to the ball-valve occlusion of the cystic duct. In a series of 10 strawberry gall bladders with stones, confirmed at operation, the average emptying time was four hours. We have found the average emptying time of the normal gall bladder to be four hours. In chronic cholecystitis without stones, there is considerable retention of dye at five hours, and in chronic cholecystitis with stones, emptying is still more delayed. Occasionally, emptying time in a strawberry gall bladder with stones may be longer than that observed in cases showing more advanced disease. This is due to the fact that there is greater activity in the strawberry gall bladder, with consequent greater displacement of stones and hence a greater probability of occlusion of the cystic duct (Fig. 4). In either case, the gall-bladder shadow may be seen to diminish rapidly in size following ingestion of the motor meal. If increased activity is observed on roentgenoscopic examination, a film should be taken 15 or 20 minutes after the motor meal instead of the customary one or more hours, since at the latter periods it will frequently show no gall-bladder shadow.

Emptying of a strawberry gall bladder may occasionally be delayed by adhesions which may be of congenital or inflammatory origin, the former being more common. The presence of abnormal congenital peritoneal attachments is usually associated with a change in the position of the gall bladder, its long axis being directed latero-medially from above downward (6). The fundus of the vesicle, therefore, points toward the mid-line (Fig. 10). Anomalous peritoneal attachments are conducive to stasis.

Discussion.—From the foregoing, it is readily seen that our description of the strawberry gall bladder is the same as that usually given for the normal gall bladder. In either case, good visibility and complete emptying are diagnostic signs. It is probably true that a good many cases reported as negative or normal are, in reality, strawberry gall bladders. It is,

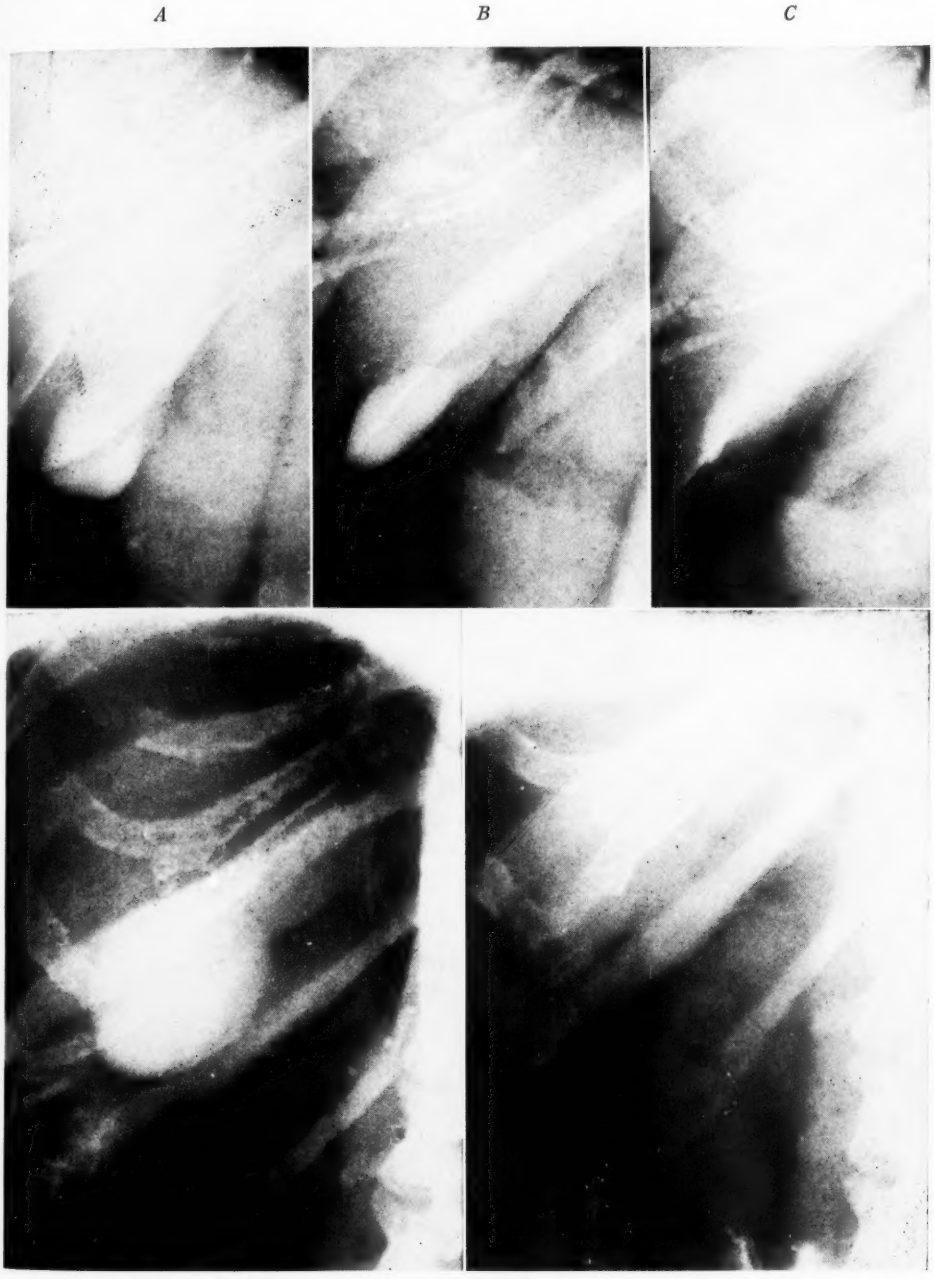


Fig. 7 (*above*). Strawberry gall bladder. *A*, film taken 14 hours after intravenous administration of dye; *B*, one-half hour after motor meal; *C*, one and one-half hours after motor meal. Note good concentration of dye and rapid emptying. The tapering of the fundus in *B* and *C*, indicating active contraction, can be observed roentgenoscopically.

Fig. 8 (*below*). Strawberry gall bladder. *A*, film taken 14 hours after double oral administration of dye. Note the dense, normal-appearing shadow. *B*, film made one hour after motor meal; the gall bladder has emptied completely. Rapid emptying is a typical finding.

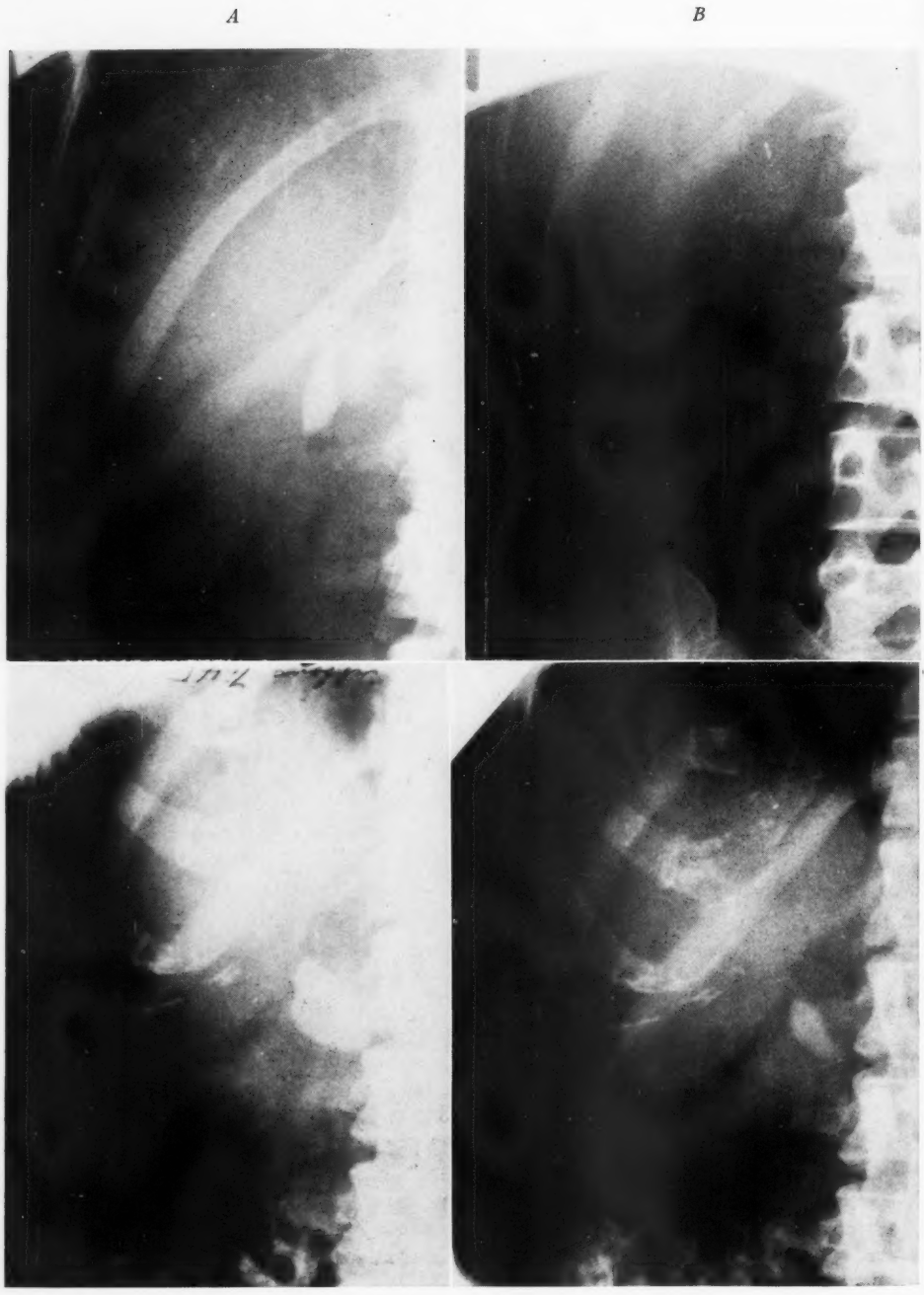


Fig. 9 (*above*). Strawberry gall bladder. *A*, film taken 14 hours after double oral administration of dye; *B*, film taken 30 minutes after motor meal.

Fig. 10 (*below*). Typical appearance of gall bladder with abnormal peritoneal attachments. The fundus of the vesicle is directed toward the mid-line. Anomalous peritoneal attachments may be conducive to stasis.

therefore, necessary to recognize additional criteria for diagnosis, and we place our reliance upon the following: good visibility, active contractions, good compressibility, local and reflex tenderness, and rapid emptying.

It is worthy of note that of 32 cases reported as strawberry gall bladder on the basis of the diagnostic signs just described, 30 were found at operation to have evidence of cholesterosis (Table II). Two cases were classified by the pathologist as chronic cholecystitis. (In these two cases, there was an average lapse of two months between roentgen examination and operation, and it is possible that further involutionary changes, found at operation, occurred in the interval.) Thus, while in 100 per cent of these cases the gall bladder was found to be diseased, roentgen examination showed good gall-bladder shadows which disappeared completely after the fat meal. The present series is small because most of the cases which we have diagnosed as strawberry gall bladder have not gone to operation. We nevertheless feel impelled to report this group of cases in order to focus attention upon the earlier recognition of gall-bladder disease and to raise a question of doubt as to the reliability of the unqualified "negative" diagnosis. The paucity of literature dealing with the roentgen diagnosis of strawberry gall bladder indicates the need for corroborative investigations along these lines.

Rossi (7) considered poor concentration of dye to be a typical element of the diagnostic picture. In this we do not concur, and it is our opinion that his conclusions were due to the fact that his cases had gone beyond the stage of simple cholesterosis and that, while changes of lipoidosis were still visible, they were, in reality, cases of chronic cholecystitis. The strawberry gall bladder usually presents a good concentration of dye on the roentgenogram. This is perhaps the most important factor which militates against its recognition.

Summary.—The strawberry gall bladder is commonly unrecognized because the usual technic of cholecystographic examinations is inadequate. These cases are frequently reported as "negative" or "normally functioning" gall bladders. Our experience with 100 cases, of which 32 have gone to operation, raises a question of doubt as to the reliability of the unqualified "negative" diagnosis.

Our technic of cholecystography and the diagnostic signs of the strawberry gall bladder are described.

TABLE II.—PATHOLOGIC FINDINGS IN 32 CASES

Cholesterosis	28
Chronic Cholecystitis	2
Cholesterosis and Chronic Cholecystitis	2
Diagnosis of Cholesterosis Confirmed (%)	87
Diagnosis of Pathologic Gall Bladder Confirmed (%)	100

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DISCUSSION

Nathan B. Newcomer, M.D. (Denver, Colorado): It is indeed a pleasure and an honor to discuss this interesting paper, delivered by Dr. Levene, on cholesterosis, lipoidosis, or the strawberry gall bladder, which was first recognized by Virchow in 1857, definitely described by Moynihan in 1909, and named by MacCarty the "strawberry gall bladder" because of its resemblance to a strawberry.

Boyd states that the deposits are cholesterol ester and thinks there is a disturbance of metabolism with an increase of cholesterol in the blood and bile, and also

states that the condition is always accompanied by a mild degree of chronic inflammation.

Moynihan, in an article entitled "A Disease Requiring Cholecystectomy," states that the number and size of the fine stones increase as the cystic duct is approached; at the beginning of the duct they stop abruptly in a perfectly straight line. He further says, "I have met with every grade of cholecystitis from the mildest to the very severe."

Obviously, such a gall bladder should fill, concentrate the dye, and empty readily in the early stages. When the dye is given, two-thirds of the non-visualized gall bladders contain cholesterol stones. This is probably an advanced stage of cholesterosis. In the later stages, there should be all stages of filling and emptying, depending on the degree of cholecystitis present.

In 1919 MacCarty reported that in a series of 5,000 gall bladders, 18 per cent were strawberry gall bladders.

Weiss states in his book, "Diseases of Liver, Gall Bladder, Ducts, and Pancreas": "The local signs of cholesterosis are extremely varied and are in no way dissimilar to those usually associated with chronic cholecystitis." He says that the diagnosis of cholesterosis must depend upon either the exclusion of grosser lesions or upon special methods of examination. He quotes Illingsworth as showing that the administration of sodium tetraiodophenolphthalein invariably resulted in a dense normal shadow of the gall bladder which diminished in size after a fat meal.

In discussing strawberry gall bladder, Rossi states: "The stomach, whatever its position, shape, or volume, shows hypermotility, especially in its pyloric antrum."

I believe I have read an article by Dr. Levene, written in 1932, in which he says: "Stimulation by the motor meal elicits active contraction of the gall bladder."

We have repeatedly called attention to the intimate relation of the antrum and cap to the gall bladder. Active peristalsis causes pressure on an inflamed gall bladder, with consequent pain.

Comment on the Diagnostic Signs.—Two of them—good visibility and good compressibility—are equally characteristic of a normal gall bladder.

In regard to early emptying time, the rate of emptying of the gall bladder varies within such wide limits in the different types of habitus and in the same individual at different times that I do not believe any great importance can be given to it as a diagnostic sign.

Tenderness over the right costodiaphragmatic angle often occurs in duodenal ulcer and in kidney lesions. That leaves local tenderness over the gall bladder. This is characteristic of acute or subacute inflammation of the gall bladder, whatever the type of pathology present. Obviously, any other pathology which might cause tenderness in the upper right quadrant would have to be excluded.

Since it is generally agreed that surgery is the solution of the strawberry gall bladder, it is a great help if the roentgenologist can confirm this method of diagnosis in early cases. The outstanding point to be considered is a gall bladder which responds normally to the dye test but which is tender to pressure; in addition, all other pathology in the right upper quadrant must be excluded.

B. A. RHINEHART, M.D. (Little Rock, Arkansas): While listening to Dr. Levene, I have learned something this morning. But here is another case in which nutritional deficiencies seem to have a direct relationship to the disease entity. In other words, Dr. Levene has said that a majority of these cases follow pregnancy. We all know that pregnant women, and women following pregnancy and lactation, are notoriously nutritionally deficient. He has further emphasized that nutritional deficiency by claiming that there is an increased muscular activity of the gall-bladder muscles, which, of course, is a calcium deficiency.

I want to ask Dr. Levene if in taking the history on these cases he has noticed the other symptoms of neuromuscular

deficiency such as spastic colon, colospasm, localized colospasm, bronchospasm, backache, neck ache, fatigue, insomnia and general cussedness or emotional instability.

GEORGE LEVENE, M.D. (*closing*): As far as the comments of Dr. Newcomer concerning the treatment of strawberry gall bladder go, we have nothing to say. We do not know. I can merely tell you what we have observed in our own experience of 32 cases that have gone to operation: 25 per cent of them still have symptoms of cholecystectomy; the few cases we were privileged to follow after medical treatment did not get any better and some of them grew worse.

It is my own feeling—and this answers also some of Dr. Rhinehart's questions—that the strawberry gall bladder is a metabolic disease primarily; that it is associated, as shown by the history and other experiences which we have accumulated in collateral lines of investigation, with a glandular disturbance probably involving the ovaries, liver, and possibly the suprarenal cortex and pituitary gland; that there must be vitamin deficiencies and calcium disturbances; but we have a strong feeling that what you say will be borne out.

Our diagnosis is aimed at the recognition of the early changes of cholesterosis because we feel that if we are to be of any value in the prevention and treatment of disease, it is much better to recognize these things early, and the typical picture which we present is that of the early strawberry gall bladder.

As the disease goes on and stones form and changes of chronic cholecystitis develop, the roentgenologic appearances vary.

I was privileged, a number of years ago, to be associated with Dr. Lester Whitaker in my work, and Dr. Whitaker, as you know, has done a tremendous amount of research in the investigation of gall bladder. At one time we used to combine barium sulphate with our motor meal, principally because of the chance it gave us to see the action of the gall bladder in company with the stomach, our feeling being that the gall bladder is an organ of digestion and so its activity must in some way parallel the activity of the stomach. And it does!

For example, we were able to compress the pylorus by manual pressure so that no barium–fat mixture could get out and we kept up the pressure until our arms got tired, examining the patient every few moments to see what was happening and then keeping it up for thirty minutes. Shortly after the pressure was released and the fat–barium mixture had gone into the duodenum, we could observe active contraction of the gall bladder.

As far as the diagnosis being based mostly on direct tenderness, we do not quite agree. We feel that good visibility is one of the diagnostic signs. We feel also that active contraction is a diagnostic sign; the good compressibility of the wall as well as direct and reflex tenderness.

This whole group of findings constitutes the classical picture of a strawberry gall bladder as we see it. Occasionally one or two signs may be absent as they may be in the findings of any disease; nevertheless, we present the classical picture.

Tenderness on the right costo-vertebral angle may, of course, be due to other conditions. In our experience, it is not due to the kidney, because kidney tenderness is considerably lower than costo-vertebral angle tenderness, and while you may get tenderness there from a duodenal ulcer, it still does not vitiate the value of this sign in diagnosis, any more than you might say fever is a sign of so many different diseases.

Therefore, it is not diagnostic but it is a useful sign when combined with other things.

THE MODIFYING INFLUENCES OF SILICOSIS AND SILICOSIS WITH INFECTION UPON THE HEALTHY CHEST[1]

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FOR years, the spectacular roentgen findings of pneumoconiosis were regarded with passive interest. More recently, because of the occupational importance of the disease and its controversial medico-legal aspects, it has received considerable recognition. At the present time, it is generally conceded that the roentgen examination when properly done is the most precise method for determining pulmonary changes in patients suspected of having pneumoconiosis.

The absence of pathognomonic signs and symptoms in pneumoconiosis has placed a heavy responsibility upon physicians interpreting roentgenograms in questionable cases. It behooves these men, therefore, to become thoroughly familiar with (1) the anatomy of the chest and its physiologic changes; (2) the normal roentgenographic and fluoroscopic appearances and their permissible variations; (3) the histology of the lungs and pulmonary lymphatics; (4) the pathology of pneumoconiosis and the diseases with which it may be confused; (5) the roentgenographic appearances of pneumoconiosis and the conditions simulating it; (6) the physical background involved in the production of pneumoconiosis, and (7) the proper technic for obtaining the most diagnostic chest films.

Pneumoconiosis is a general term for the condition induced by the long-continued inhalation of dust. A discussion of the entire subject is beyond the province of this report. Our remarks will be confined to silicosis, a condition of the lungs caused by the inhalation of free silica.

For years, physicians have classified silicosis according to the degree of lung involvement. These classifications have overtly connoted continued activity and progressive changes as the result of the silicotic invasion. Recent experiences with workers in pure silica have led us to endorse a more simple classification. This classification divides silicosis into two large groups: (*a*) simple silicosis, and (*b*) silicosis with infection, which is more simple and probably of more practical value. The various "stages" of silicosis used in other classifications may be explained on the basis of coexisting respiratory infections and the modifying influences of respiration and other contaminating dust.

According to Miller (1–4), the lymphatics of the lung may be divided into two main systems. One of them, the deep lymphatics, courses through the lung as a series of vessels which follow the bronchovascular tree toward the hilum. The other, or superficial set, runs through the pleura and empties into the tracheobronchial nodes. These two systems communicate in the periphery of the lung through a series of short lymphatic vessels containing valves which allow lymph to escape from the deep-set into the superficial lymphatics. In addition, there exist small tufts of lymphoid tissue which may be found in the walls of the primary lobule. Sheath-like dispersions of lymphoid tissue may also be identified around the bronchovascular tree. Though rarely found in human lungs under 30 years of age, this sheath-like formation of lymphoid tissue becomes more conspicuous with the advent of middle life and probably accounts for the prominent bronchovascular markings frequently found beyond the age of 60.

Inhaled dust, like bacteria, may be caught in the protective mechanisms of the upper respiratory tract. If the silica dust escapes these protective devices and

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reaches the primary lobules, the earliest processes which eventually lead to the formation of silicotic fibrosis manifest themselves. Silica particles reach the perialveolar lymphoid deposits through alveolar pores or dust cells. Here, these particles penetrate into the substance of the nodule or are carried along the lymphatic stream to some position close to the hilum. Gardner's (5) experimental studies have demonstrated that the character of the ingested foreign material exerts a marked influence upon the behavior of dust cells. Carborundum, or soft coal dust, tends to remain in the peripheral air spaces because dust cells become engorged with these substances, thereby reducing their power of locomotion. On the other hand, quartz is ingested in much smaller quantities which seems to stimulate and allow more rapid migration.

When the local concentration of silica is sufficient to stimulate the connective tissue cells supporting the lymph nodules, the latter become transformed into a nodule of fibrous tissue. Eventually the expanding area of fibrosis encroaches upon and compresses adjacent lymph channels. As the fibrotic process continues, the channels become narrower, with interference of drainage to the tracheobronchial nodes. Since the lymphatics course along the walls of the blood vessels and bronchi, these structures appear thickened. The hypertrophied lymph nodules along the course of the bronchovascular tree give them a beaded appearance.

Following these preliminary stages, dust continues to accumulate in the lung with subsequent involvement of the walls of the air spaces. Excessive concentrations of silica may produce thickening of the septa between alveoli and thus produce interference with the gaseous exchange of oxygen and carbon dioxide.

Roentgen Considerations.—The earliest roentgen lesion that we accept as evidence of simple silicosis is nodulation or the conglomerate shadows. Prominent trunk or bronchovascular markings without nodulation or the conglomerate shadows are not recognized as sufficient roentgen evidence upon which to base a diagnosis of silicosis.

Simple silicosis is characterized by the presence of small, discrete nodules of fibrous tissue disseminated throughout both lungs. The lesions and the shadows cast by them tend to be spherical, hard, sharply defined, and vary in size from two to six millimeters. While the distribution is usually uniform throughout both lungs, the extreme apices and the outer portion of the bases are frequently uninvolved in the roentgenogram. In less advanced cases, the nodules remain discrete and separated by air-containing tissue.

There are some investigators who state that in simple silicosis, conglomerate shadows may develop from a combination or coalescence of discrete nodules or as a conglomerate lesion primarily. The resultant lesion and the shadow that it casts are often difficult to distinguish from the conglomerate shadows of silicosis with infection. It is generally assumed that conglomeration results from accidental overlapping and fusion of discrete nodules when they become very numerous, but since conglomeration is usually a localized affair and does not occur in the same portion of the lung of every individual, it is logical to inquire why the nodules happen to fuse in one portion of the lung and not in others. Microscopic examination of the tissues from such areas reveals no evidence of active infection. The nodules seem to be much closer together than in other portions of the lung, they are less uniform in size, and they are usually embedded in a matrix of diffuse fibrous tissue having the same characteristic hyaline appearance as that forming the nodules themselves. It seems probable that conglomeration may have occurred because the portion of the lung in question was previously damaged by a localized inflammatory process occurring before or during the early period of dust exposure. More dust would tend to accumulate in such an area and possibly the nodules would develop irregularly and would frequently be very close together, thus producing the conglomerate shadow.

Nodulation and conglomerate nodulation have been included under simple silicosis because of common usage. At one time, we accepted nodule formation as unqualified evidence of simple silicosis. Recently, we have begun to doubt the accuracy of this concept. In studying the roentgenograms of a large number of individuals working in pure silica from ten to forty years, we have found a large percentage with no roentgen or clinical evidence of disease. In the same group, we have found individuals exposed for only a few years with massive pulmonary changes, while others exposed for twenty to forty years showed no demonstrable changes. When one encounters this type of variation in a number of individuals in a silica industry, one cannot help but question the ideas concerning individual susceptibility or factors concerned in the production of lung changes. We believe infection to be the most important modifying influence that causes one individual to have nodulation or some other silicotic lesion while another shows no lung changes. Likewise, we have observed nodular lesions which have remained unchanged in the same individual for years. If silicosis is always progressive, one should expect to see the lesion increase in size or change to some extent. If, on the other hand, the nodulation was produced by silica plus infection, one could readily understand why the lesion would remain unchanged if the infection were quiescent. In such individuals, we believe the nodulation represents silicosis with a healed or quiescent infection.

Before considering silicosis with infection, one might profitably review the dynamics of the chest and its relation to lymphatic flow.

Considerable evidence has accumulated substantiating the belief that massage, passive motion, capillary damage, increased venous and capillary pressure, and decreased blood proteins accelerate lymphatic flow. The importance of these findings may be appreciated when one realizes that the rate of lymph flow and the progress of phagocytes within lymph vessels are negligible when the part being studied is at rest. Recently, several investigators have reported that unilateral pneumothorax produced a decrease of about 45 per cent in the flow of lymph from the lungs. These data seem to indicate that the respiratory excursions of the lungs and the massaging action of the pleura play an important rôle in pulmonary lymph flow.

During inspiration, the first five ribs rotate up and out, carrying the sternum forward and upward. These movements increase the anteroposterior dimensions of the chest, expanding the upper lobe in an anteroposterior direction. The inspiratory forces produce expansion in a forward, downward, and outward direction with considerably more expansion taking place in the lower lobes than in the upper.

Working against these inspiratory mechanisms are the heart, the vertebral column, and the vertebral portions of the ribs. Being relatively fixed structures, the lung nearby cannot move and expand to the same extent as the lung periphery.

The ribs maintain a constant relationship with the upper lobe in its excursions, with the result that the impressions of the first five ribs may frequently be seen after death, due to the massaging action of the chest wall. Such markings are unusual in the lower lobes because the lungs are drawn downward during inspiration by the powerful action of the diaphragm, thereby massaging its pleural surfaces against the long axis of the ribs. The relative lack of anthracotic pigment in pleural surfaces exposed to the more pronounced massaging action of respiration also supports the hypothesis that respiration and massage are important factors in lymph flow. This seems tenable since other portions of the lung around the heart and in the costophrenic sulci are also less pigmented.

Under normal conditions, absorption of blood proteins represents the main task of the lymphatics. With infection, there may be added the removal of cellular detritus, dust, bacteria, and so forth. Ac-

cording to Drinker (6), lymph collected from regions of inflammation is high in proteins and enmeshed white cells. This abnormal tissue fluid acts as a culture medium unusually well suited for the growth of fibrous tissue. Fibrous tissue overgrowth is also accelerated when there occur high degrees of venous obstruction accompanying lymphatic obstruction.

Silicosis with Infection.—In this group are included all cases with detectable evidence of infection, whether active or inactive.

During the active period of some infections, the lesion, we believe, extends to the periphery of the lung in many instances. Areas of mottling (shadows varying in size with ill defined borders and lacking uniformity in density and distribution), either exudative or productive, may involve different parts of one lung, or both. The nodular lesions previously described may assume the characteristics of soft nodulations with fuzzy, irregular borders. Instead of discrete lesions, the shadows of the borders blend imperceptibly into that of the surrounding lung.

Massive shadows of homogeneous density characterize the advanced lesions of silicosis and infection. Usually, the architecture of the lung in the region of the massive changes is entirely obscured. Overexposed films are necessary to penetrate the extremely dense intrapulmonary areas and in order to attempt to analyze their internal structure. Manifestations of infection depend upon the nature of the infecting organism; if tuberculous, calcification or small cavities may be identified. It is well to remember that a fair percentage of these infections may be non-tuberculous in origin. With all these criteria of activity, the only safe procedure for roentgenographically determining the activity of a silicotic process is to make serial examinations.

In healed infections, the hila may be considerably increased in prominence, but usually the hila are not noticeably enlarged. The bronchovascular markings may be quite prominent. The lungs shadows include localized discrete densities, string-like conglomerate shadows, and beginning massive fibrotic areas which do not extend to the periphery of the lung. In one industry, we have seen eight cases of extensive enlargement of the hila that have remained unchanged over a period of four years. In the absence of nodulation or conglomerate shadows, one hesitates to make a diagnosis of silicosis in such an individual. We have felt, however, that one could exclude childhood tuberculosis because of the absence of calcification. A malignant lymphoma was excluded because of the lack of change for such a long time in the size of the lesion.

We have used the position of the lung shadow as additional evidence as to whether a lesion is active or quiescent. For years, radiologists have been concerned as to the explanation of the clear peripheral zone lateral to the large conglomerate lesions in silicosis. Recently, in serial studies of individuals having silicosis with a subsiding active infection, it was noticed that a lesion that at one time extended to the pleural surface began to clear at its periphery and subsequently there developed a clear zone of lung between the lateral portion of the lesion and the thoracic wall. The clear zone developed during the period when the patient was overcoming the infection. On other occasions, a central lesion became infected and, with it, the roentgen shadow extended to the pleural surface.

Such experiences have led us to explain the roentgen findings on lung dynamics. During the period of active infection, the lung becomes sufficiently fixed to interfere with the massage action of the ribs and other respiratory forces. This allows the roentgen shadow to extend to the periphery. With the subsidence of the infection, the massage and respiratory forces again become operative, lymph flow is improved, and the peripheral lung gradually clears.

If the tuberculous process or a Friedlander's pneumonia were present unilaterally before the silicotic process became

manifest, the trachea may be displaced to one side; whereas if the silicotic process were present first, the trachea is usually in the midline.

For years, silicosis, especially silicosis with infection, has been looked upon as a progressively fatal disease. Increasing experience with pure silica workers has given us a new optimism with respect to the future of patients with silicosis. Fibrosis of any origin, interfering with the normal massage action of the lung, predisposes to the accumulation of silica and pulmonary fibrosis. If factors favoring further fibrosis, such as additional silica, vascular stasis, or infection are avoided, there is no reason why patients with minimal fibrosis may not remain well. On the other hand, if chronic or acute pulmonary infections supervene, there is little that can be done to prevent fibrous overgrowth and progression to massive fibrosis. The important practical procedures are to limit the hazard in patients with stabilized lesions and to remove from the industry men with evidence of superimposed active infection. These men, if properly guided, may be returned to health even in the face of an active infection.

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SILICO-TUBERCULOSIS AS SEEN IN A LARGE INDUSTRIAL CENTER[1]

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From the Herman Kiefer Hospital

IT has been said that the problem of silicosis in industry has been pretty well eliminated as far as present-day hazards are concerned, and further, that in those States in which compensation laws dealing with this condition have been established, most of those cases suffering from silicosis have been brought to light and very few new ones are now appearing.

This is to a large extent true in the experience here reported as far as preventive practices in the larger industries are concerned, but there is still an appreciably significant number of men who were exposed to silica dust years ago and who are coming to light now with silicosis and superimposed tuberculosis.

It is, therefore, the purpose of this discussion to report the experience with silico-tuberculosis of the Herman Kiefer Hospital Tuberculosis Division over a period of five years from 1933 to 1938. This hospital serves the industrial community of Detroit, which would suggest that there are or have been many possible silica dust hazards in the various industries represented in such an area. In addition, the migration of many workers from other parts of the country to Detroit in recent years has resulted in many men who have worked in hazardous dusty trades for longer or shorter periods coming to this community and later being found to have silico-tuberculosis. In these cases the silicosis was undoubtedly the result of exposure elsewhere as, in many instances, no dust hazard existed in the new work in which they engaged.

The diagnosis of silico-tuberculosis is not always easily made and must rest on making a diagnosis of two co-existing conditions. In making the diagnosis, then, the following points for tuberculosis must be considered: the appearance of the roentgenogram, the presence or absence of tubercle bacilli in the sputum, evidence of cavitation, and symptoms. For silicosis a typical roentgenographic appearance, history of prolonged exposure to silica dust, and symptoms are important. Autopsy findings, of course, are final in confirming the diagnosis of silico-tuberculosis, though it is well known that it requires careful observation on the part of the pathologist to recognize both the conditions as being present.

From Oct. 1, 1933, to Sept. 30, 1938, a five-year period, there were admitted 171 men in whom a tentative diagnosis of silico-tuberculosis was made on admission. More careful study revealed, however, that only 132 of these were definitely confirmed as having silico-tuberculosis, as shown in Table I.

TABLE I.—TENTATIVE DIAGNOSIS OF SILICO-TUBERCULOSIS: 171 CASES

Silicosis and no tuberculosis.....	8 cases
Tuberculosis and no silicosis.....	31 cases
Silico-tuberculosis.....	132 cases

During the five-year period there were 3,914 males admitted to the hospital and, of these, 132 (3.37 per cent) had silico-tuberculosis.

The basis on which this diagnosis is shown for tuberculosis:

X-ray suggestive	132
Tubercle bacilli in sputum	113
Cavity present by x-ray examination	109
Autopsy	12
No cavity or positive sputum or autopsy but x-ray, symptoms, and signs definite	7

[1] Presented before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2. 1938.

For silicosis, the following findings were noted:

X-ray suggestive	132
History of exposure to silica dust	129
Proved at autopsy without history	2
Autopsy with history	10
No history, but appearance very definite	1

Combining these findings it is, therefore, felt that a very definite diagnosis of silico-tuberculosis could be made in these 132 cases.

The history of exposure to silicon dioxide is essential, as all will agree, in establishing the diagnosis of silicosis. In this series, coming as the cases do from many different industries and having been employed in many different localities, it is interesting to note the occupations represented. Foundry workers outnumber all the others, as might be expected in an industrial manufacturing center. There is, however, a significant number of miners, all of whom had their exposure to dust elsewhere than Detroit.

The length of exposure to silica is, in all these groups, quite long and in many instances the interval since the exposure last occurred and the time of diagnosis is quite protracted. The average age of all these workers when the disease was diagnosed was 50.2 years, the average exposure 17.4 years, and the average interval since exposure 4.9 years. These same averages for each group of workers are shown in Table III.

The ages at which the diagnosis was made finds a few in the fourth decade of life, but most of them occur after 40 years of age. In one instance a man of 24 who had worked for six years as an enameler on iron in a stove works, died as the result of extensive tuberculosis superimposed on silicosis. This was proved silico-tuberculosis at autopsy. There were three instances of men of 70 years or over, the oldest being 74. One of these was a foundry laborer all his life, another a stove works foundry laborer for 20 years, and another a grinder with various types of wheels.

TABLE II.—OCCUPATIONS

Foundry Workers:		
Moulders	28	
Foundry laborers	26	
Sand blasters	14	
Stove works employees	5	
	—	73
Miners:		
Coal	16	
Gold and quartz	7	
Copper	3	
Iron	1	
Type not known	1	
	—	28
Grinders:		
Dry	11	
Metal finishers	3	
	—	14
Stone Cutters		9
Cement Workers		5
Unknown		3
		132

The age distribution on diagnosis was as follows:

Age	No. of Cases
20–29	1
30–39	11
40–49	49
50–59	50
60–69	18
70–	3
	132
Average age	50.2 years

The treatment of silico-tuberculosis is very unsatisfactory and attended with practically no success. Uncomplicated silicosis has no treatment and even after dust exposure has ceased, is usually progressive. In the presence of infection Gardner (1) believes that the condition progresses more rapidly and that massive conglomerate nodulation in silicosis only occurs in the presence of an inflammatory process. In any event, most will agree with Taylor and Alexander (2) that there is no treatment for silicosis as such.

For tuberculosis alone, bed rest and the various forms of collapse therapy are successful in arresting the disease in many instances. In the presence of silicosis, however, as shown by the following experience, the use of collapse therapy is usually contra-indicated. Bed rest, then, is all that is left, which, in the face of this condition, is not sufficient except in a few

mild silicotics with litttle tuberculous involvement. Even in these cases, it tends to prolong life only rather than arrest the disease.

In this series there were 21 patients in one must wait for an average of six months and often longer before return of function occurs. This may mean serious respiratory embarrassment if dyspnea has occurred following this type of operation.

Fig. 1.

Fig. 2.

Fig. 1. Extensive silico-tuberculosis with cavitation in the right lung.
Fig. 2. Same case as shown in Figure 1, with right pneumothorax.

whom collapse therapy was employed. There were 18 of these who had pneumothorax for varying lengths of time, 11 of whom had the pneumothorax given up because of severe dyspnea after an average of 3.9 months of treatment. Eight of these 11 are now dead. In five others the pneumothorax was given up after an average of 4.1 months because it was ineffectual, and three of these are dead. One patient, who had fair success for 12 months, gave up the treatment wilfully and soon died. Of all these, only one case has been at all successful and that one is now an arrested case after 39 months of pneumothorax treatment. This experience is shown in Table IV.

Phrenic nerve surgery is even more unsatisfactory in the face of silicosis for, in pneumothorax, the lung can usually be re-expanded, whereas with even a temporary paralysis by crushing the nerve,

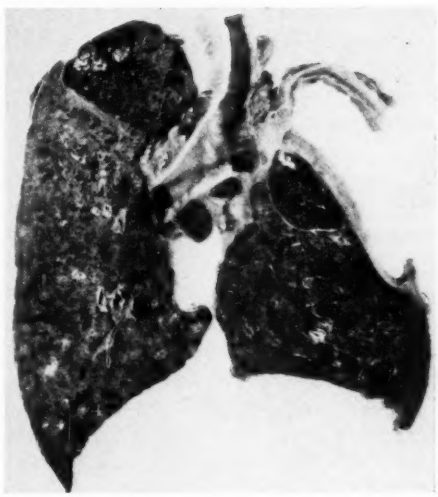


Fig. 3. Same case as shown in Figures 1 and 2, lungs at postmortem show massive silicotic fibrosis in the partially collapsed lung. Massive silicotic involvement in the left upper lobe.

Six of the patients in this series were subjected to phrenic nerve surgery in the form of crushing the nerve for temporary paralysis of the hemidiaphragm. Three of these followed ineffectual pneumothorax and three others were done without other procedures being used. Of the six, three are dead, two are failing, and only one is apparently arrested and seems to be doing well. So that of the 21 cases of silico-tuberculosis whose outlook was thought to be above the average and who might be benefited by collapse therapy, only two can be said to have done well, one with pneumothorax and one with phrenic surgery.

TABLE III

Occupation Group	Number	Age, Average	Years of Exposure in Years, Average	Interval Since Exposure: Years, Average
Foundry workers	73	49.9 years	17.0 years	4.2 years
Miners	28	51.3 years	18.8 years	8.0 years
Grinders (dry)	14	49.8 years	12.4 years	0.8 years
Stone cutters	9	54.0 years	23.6 years	7.3 years
Cement workers	5	52.8 years	16.0 years	2.2 years
Unknown	3	53.0 years	..	..
All workers, average	132	50.2 years	17.4 years	4.9 years

TABLE IV

Progress of Pneumothorax	No. Patients	Average Duration of Pneumothorax	Improved	Unimproved	Dead
Given up because of dyspnea	11	3.9 months	0	3	8
Ineffectual	5	4.1 months	0	2	3
Given up own volition	1	12 months	0	0	1
Successful	1	39 months	1	0	0
	18		1	5	12

In previous years other cases were tried with equally poor results, so that collapse therapy seems to have nothing to offer the silico-tuberculosis case and may even hasten the progress of his disease. This is well illustrated in one case of conglomerate massive silico-tuberculosis with fibrocaseous cavernous involvement in which the attempt to collapse the cavities seemed to result in hastening the progress of the massive fibrosis and made it impossible to re-expand the lung when embarrassment to respiration occurred.

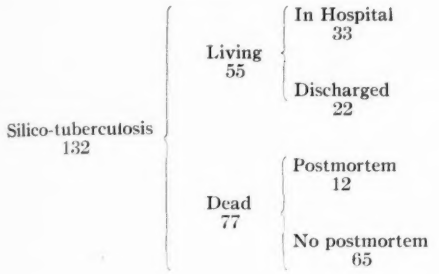
It is difficult to measure the respiratory function and determine the degree of impairment of the pulmonary physiology produced by various disease processes. Whitehead (3) has recently devised an ingenious method of evaluating the pulmonary function by measuring the ability of the patient to oxygenate his blood while breathing room air as compared with breathing a low (16 per cent) oxygen air. The normal individual will show only a small decrease in the oxygen saturation in his blood while breathing 16 per cent air, whereas the person with impaired lungs will show a definitely greater lowering of oxygen content of the blood in breathing low oxygen air. The vital capacity gives no inkling of this impairment in many instances and this is particularly true of silicotics with tuberculosis. As an example of these findings, through the kindness of Dr. Whitehead the following observations on two silico-tuberculosis cases are shown in comparison with ten normals:

Patient		O_2 Sat. at Room Air	O_2 at 16 Per Cent Oxygen Air	Vital Capacity
W. B.	Silico-tuberculosis	94.2%	85.6%	3515 c.c.
J. C.	Silico-tuberculosis	91.4%	81.7%	2390 c.c.
Average of 10 normals		98.1%	93.1%	

It will be noted that there is a marked

drop in oxygen saturation in the blood of the silicotics. Experience with this test has already taught that these persons are bordering on serious embarrassment, hyper-ventilate on slight provocation, and would, of course, not stand further inroad on their respiratory function by any collapse procedures, in spite of the fact that the vital capacity is quite good. Treatment of silico-tuberculosis is, therefore, very unsatisfactory from the standpoint of attempting to use collapse therapy for the control of the tuberculous involvement.

TABLE V



The fate of the 132 cases in this series bears out still further the seriousness of the condition and the definitely unfavorable prognosis that must be given the individual suffering from silicosis with tuberculosis. Of the 132 patients in this study, 77 are known to be dead, 33 are in the hospital, 22 were discharged from the hospital alive, of which seven have been lost to sight and only a few of the others discharged have done well—most of them are gradually failing. Table V indicates the fate of these patients.

If grouped by years, the mortality in this series is most striking in indicating how serious the prognosis becomes with the passage of time. Of the 31 cases diagnosed during the first year of the study, 87.1 per cent were dead by the end of the five-year period, and 77 (or 58.3 per cent) of the 132 cases were dead, as will be seen from Table VI.

TABLE VI

	Total	Living	Condition Unknown	Dead	Percentage Now Dead
Oct. 1, 1933, to Sept. 30, 1938	31	2	2	27	87.1
Second Year	33	8	2	23	68.7
Third Year	27	8	2	17	62.9
Fourth Year	16	9	1	6	37.5
Fifth Year	25	21	0	4	16.0
	132	48	7	77	58.3

Tuberculosis alone has a far better prognosis, even in advanced cases, when suitable treatment can be employed. This is strikingly shown by a series of advanced cases with bilateral involvement recently reported from this service (4). Of 205 bilateral cases treated with bilateral simultaneous pneumothorax, 25.6 per cent were dead after seven years, a far more favorable finding than 58.3 per cent in five years as noted in this group of cases with silico-tuberculosis.

It is most important, therefore, that silico-tuberculosis be diagnosed accurately, for the silicotic patient without tuberculosis may, as many believe, be in definite danger when exposed to open cases of the disease by putting him in an institution. The silicotic patient does not need bed rest for he should be kept active within the limits of his physical ability. The tuberculous individual with a suspicion of silicosis should have the silicosis ruled out, for prompt application of collapse therapy may be of distinct value to him if he is free of silicosis, but a menace if he is not.

SUMMARY AND CONCLUSIONS

1. A group of 132 cases of silico-tuberculosis admitted to a tuberculosis hospital is presented.

2. The occupations of this group have been varied, the largest number, 73, having been foundry workers of various kinds.

3. The basis of the diagnosis for tuberculosis rests on x-ray evidence, sputum analysis, cavity formation, and symptoms; for silicosis, x-ray appearance, history of exposure to silica dust, and symptoms.

Both silicotic and tuberculous findings are supported by autopsy studies in 12 cases.

4. The failure of collapse therapy as a measure to be employed for silico-tuberculosis is pointed out.

5. The serious prognosis of silico-tuberculosis is emphasized and the need for making an accurate diagnosis in the interest of proper treatment stressed.

The authors are indebted for valuable assistance to C. C. Birkelo, M.D., and W. L. Brosius, M.D., Roentgenologist and Pathologist, respectively, at the Herman Kiefer Hospital.

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AN X-RAY STUDY OF THE EFFECTS OF INDUSTRIAL GASES UPON THE HUMAN LUNG[1]

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IT IS apparently the accepted belief that men who work with exposure to irritating fumes as they occur in industry develop specific conditions of the lungs as a result of this exposure. A search of the literature fails to disclose that studies, including routine serial x-rays, have been made upon an employee group so exposed. There are a few references in the literature in which isolated cases with exposures to SO_2 and chlorine are reported. These were all acute cases. An analysis was made of those cases which appealed for compensation to the British Government Board following exposures to vesicant gases during the war. Many of these cases, however, were not studied by x-ray.

Since the literature gave us no help and since we believed that a chest x-ray was essential to a more accurate diagnosis of chest conditions, and in order to determine if exposures as they occurred in industry would produce changes in the lung, an x-ray program was adopted. Serial x-rays of the chests of a large number of men in the chemical industry were begun five years ago. The remarks which follow are based upon an analysis of these serial x-rays.

All of these x-rays were taken with a standard technic. The distance was 72 in., the time one-tenth of a second at 100 ma., with the kv.p. as the only variable factor. The kv.p. was determined by exact measurement of the individual's chest with a caliper or other measuring device. The technic used in each case was recorded on the x-ray report so that this could be referred to at the time subsequent x-rays were made.

The darkroom technic was standard, namely, the films were developed for exactly five minutes at a temperature of 65° Fahrenheit. The solutions were used for a specified number of films only.

No attempt will be made to discuss acute conditions which may be caused by the inhalation of the various gases under consideration. At the present time no attempt is being made to discuss the pathology or the etiology underlying the fibrotic changes seen in the majority of the x-rays taken at the time the men began work in locations where minor exposures to the gases occurred.

During this period approximately 17,000 chest x-rays were made. This included chest x-rays of individuals working in the industry but not necessarily exposed to irritating gases. The men whose x-ray films appear in the discussion represent a random sample of the cases studied. The groups were arranged alphabetically and every fifth to eighth man was selected.

We will discuss the cases in four groups, depending upon chemical exposure. The cases in the first group consist of those men exposed to chlorine and hydrochloric acid in the manufacture of these two products. In this group 35 men were under observation. The average age is 38 years. The average service in the industry is 9.5 years, and the average service in the chlorine area is 6.4 years. The operation in which these men are exposed is considered, from the manufacturing standpoint, a modern plant. The substances are handled in a closed system. However, low-grade concentrations occur and frequently there are breaks in pipelines and failures in equipment which liberate quantities of chlorine and hydrochloric acid fumes. The men whose x-ray films appear in Figures 1 through 10 have had exposures

[1] Presented before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

ranging from seven to nine years in the routine manufacture of these products.

W. G., No. 1608, male, 28 years of age. He has had eight years' service in the industry, all in this area. No history of respiratory infection has been given during the entire period. As the x-ray examination indicates, there is no increase in pulmonary fibrosis (Figs. 1 and 2).

W. M., No. 1630, male, 50 years of age, has had seven years' service in the industry, all in this area. He was treated for a liquid chlorine burn on one occasion and gives a history of two attacks of

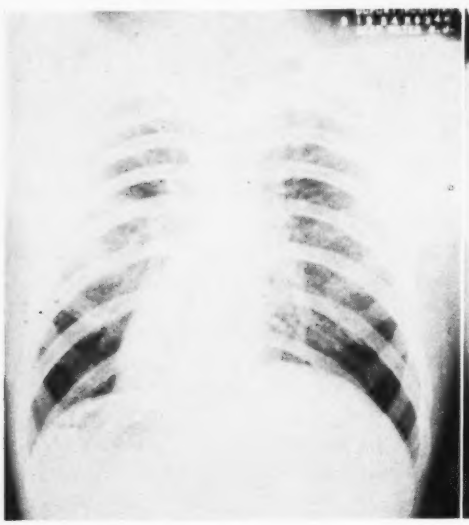

Fig. 1.

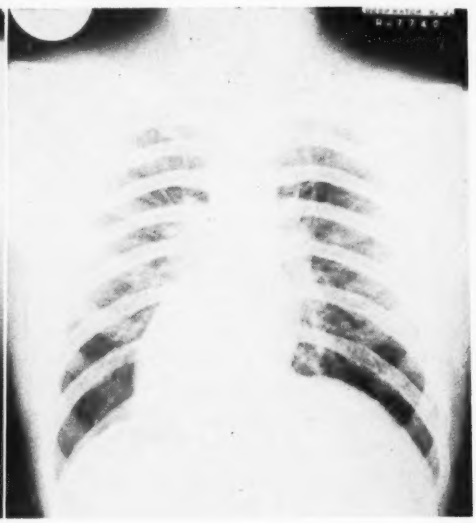

Fig. 2.

Fig. 3.

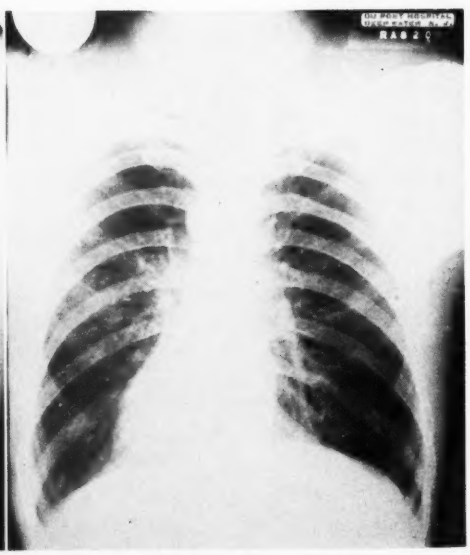

Fig. 4.

respiratory disease during the past five years. As Figures 3 and 4 indicate, there has been no increased fibrosis.

W. R., No. 1624, male, 54 years of age. He has had nine years' service in the industry, all in this area. The first x-ray examination was made in 1934, at which time inactive tuberculosis was disclosed. Following several months' observation, he was permitted to continue to work in the area. As Figures 5 and 6 demonstrate, work in this area has not adversely affected his condition and has not caused an increase or spread in the tuberculosis. The

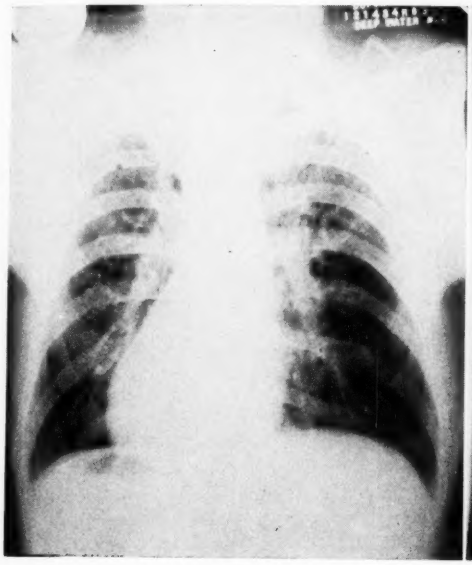

Fig. 5.

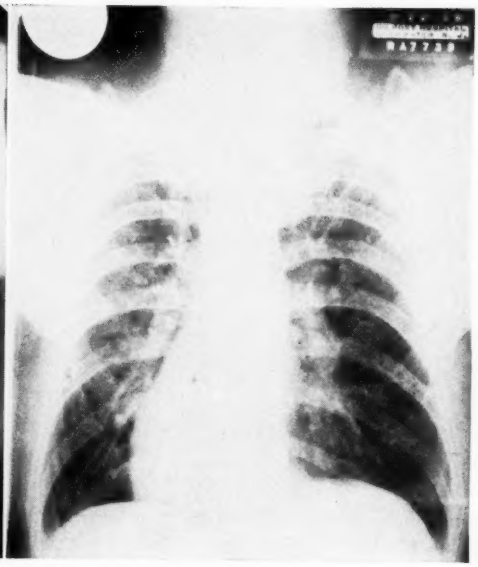

Fig. 6.

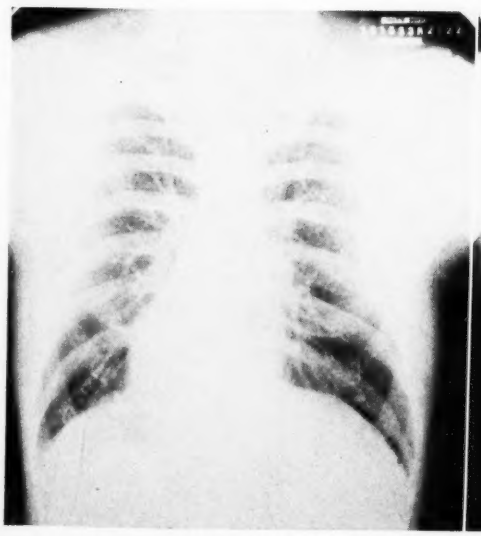

Fig. 7.

Fig. 8.

1938 film shows slightly more organization of the tuberculous process than that demonstrated in the 1934 film.

H. R., No. 1620, a foreman, 44 years of age. His total service in the chemical plant is 22 years and his service in the area amounts to nine years. During the past five years there has been a history of four respiratory infections and one treatment for chlorine fumes. As the x-ray examination (Figs. 7 and 8) demonstrates, there has been no increased fibrosis during this five-year period.

W. S., No. 1635, male, 33 years of age

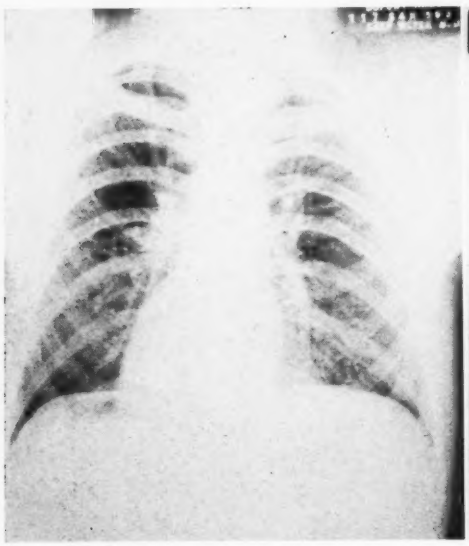

Fig. 9.

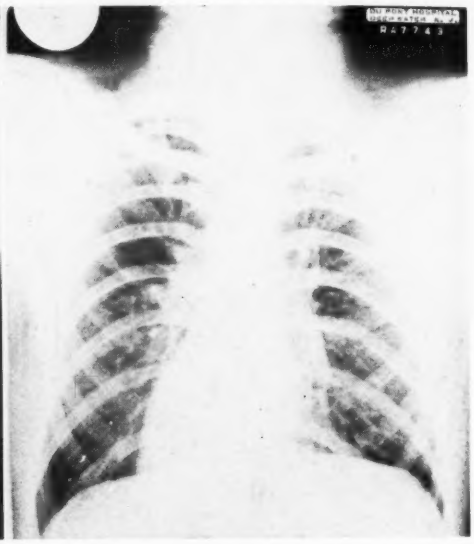

Fig. 10.

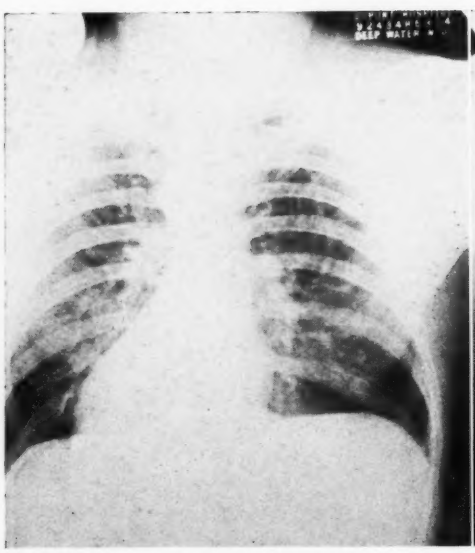

Fig. 11.

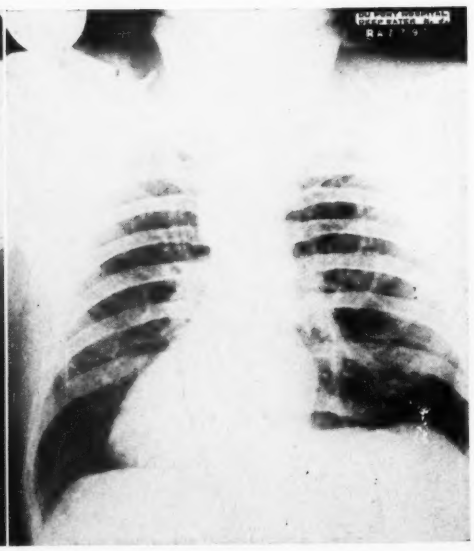

Fig. 12.

He has had 11 years' service in the industry and nine years in the chlorine area. He works as a cell-room operator in which he makes hydrochloric acid by burning hydrogen and chlorine. During the past ten years he has had only three attacks of respiratory disease. As his x-ray films (Figs. 9 and 10) indicate, during the past four years there has been no increase in pulmonary fibrosis.

The second group comprises those who have had exposure to SO_2 and SO_3 in the manufacture of sulfuric acid. Eighteen men were observed in this group. The average age is 44 years; the average service

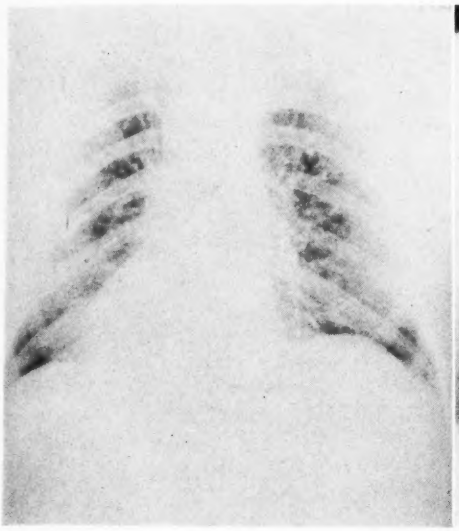

Fig. 13.

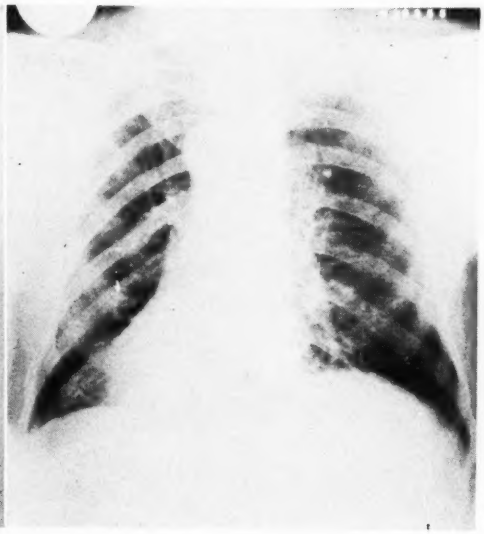

Fig. 14.

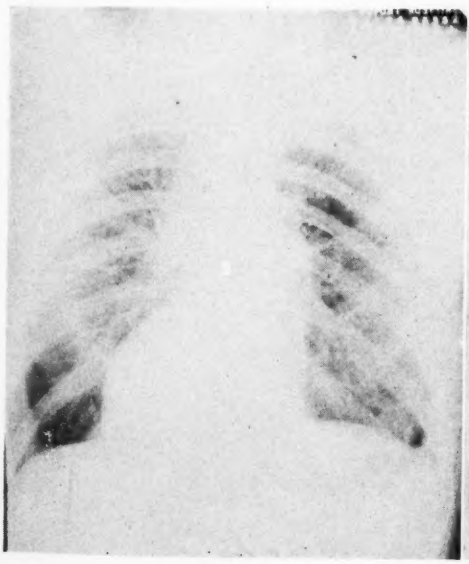

Fig. 15.

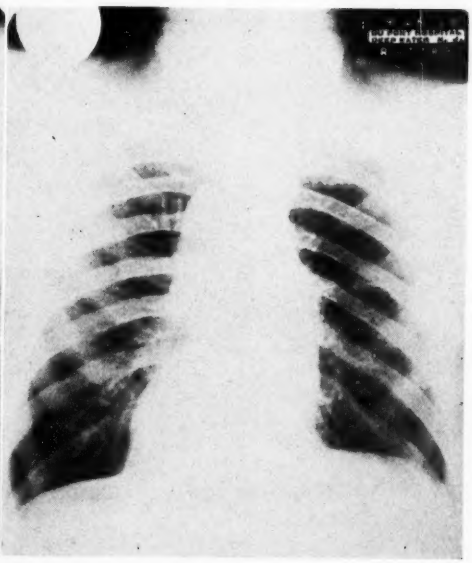

Fig. 16.

in the industry is 13.5 years, and the average service in the area is 10.7 years.

Here again the plant is a modern contact plant. However, with this operation breaks also occur and quite often the fumes are exceedingly heavy, so much so that at t'mes these men have been compelled to leave the operating building. This is particularly true when changes in equipment are necessary and when for

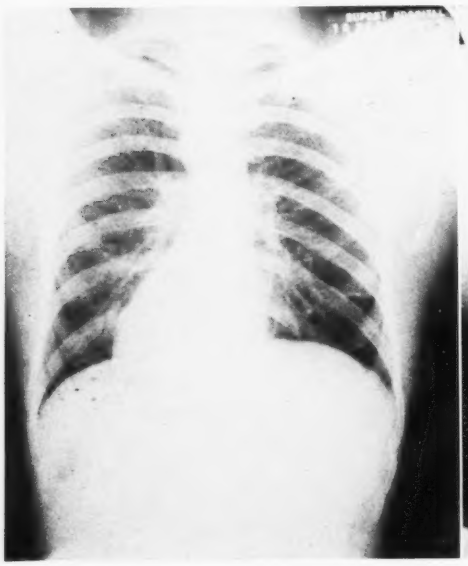

Fig. 17.

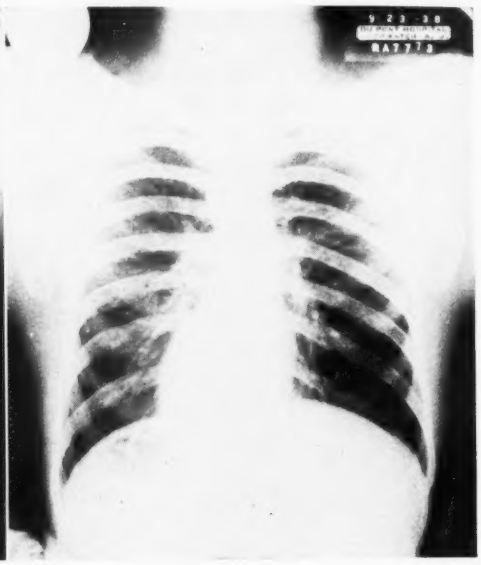

Fig. 18.

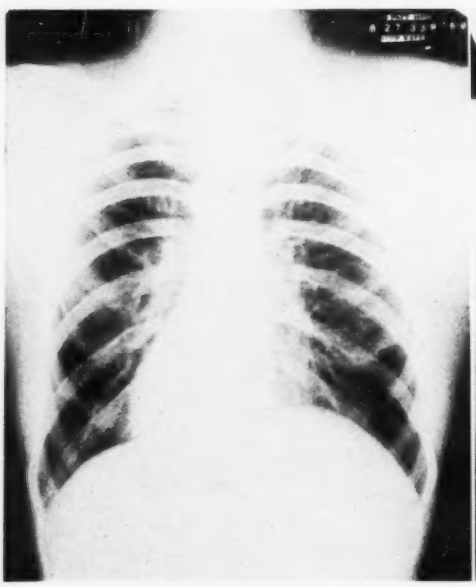

Fig. 19.

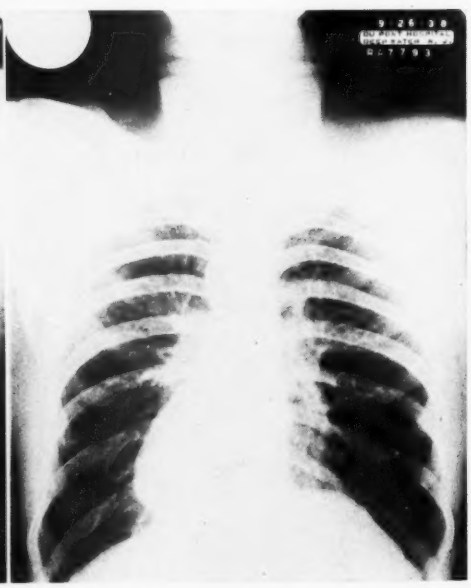

Fig. 20.

some reason it has been necessary to close down the plant which usually runs as a continuous operation. The cases we present have had exposures ranging from five to nineteen years.

W. B., No. 1187, male, 44 years of age. His total service in the industry is ten years with five years' service in the area. As the x-ray examination (Figs. 11 and 12) indicates, there has been no increased fibrosis during the past four years.

M. O. B., No. 1186, male, 60 years of age. He has had 21 years' total service in the industry and 13 years' service in the OV plant. This man has had only minor attacks of respiratory infection. As the x-ray films (Figs. 13 and 14) indicate, there is, if anything, improvement with reduction of pulmonary fibrosis in the four-year period between 1934 and 1938.

C. E. C., No. 1153, male, 67 years of age. He has had 21 years' service in the industry and 19 years' service in the OV plant. The history is negative for frequent respiratory infections. The man has lost practically no time from work except that due to one minor operation. As the x-ray films (Figs. 15 and 16) demonstrate, there is less pulmonary fibrosis shown in the 1938 film than was present in the 1934 film.

H. H., No. 1118, male, 36 years of age. He has had five years' service in the industry, all in the OV plant. As his x-ray examination indicates, there has been no change in the lung findings during this five-year period.

B. J., No. 1111, male, 43 years of age. He has had five years' service in the industry, all in this area. He has had two respiratory infections during the past five years. As the x-ray examination indicates, there has been no increased pulmonary fibrosis.

The third group consists of those men who have had exposure to hydrofluoric acid fumes and to combination products of hydrofluoric acid, mainly, that group of chemicals which are used as refrigerants.

In this group 74 men were under observation. The average age is 31.7 years; the average service in the industry is 4.9 years, and the average service in the area is 2.7 years.

The men in this group whose x-ray films are shown have had exposures ranging from four to seven years. While this

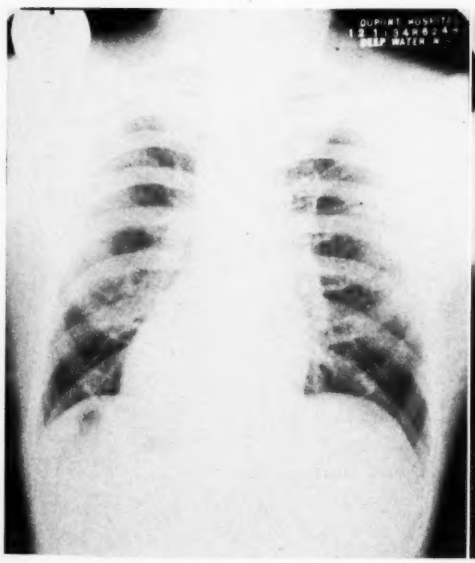

Fig. 21.

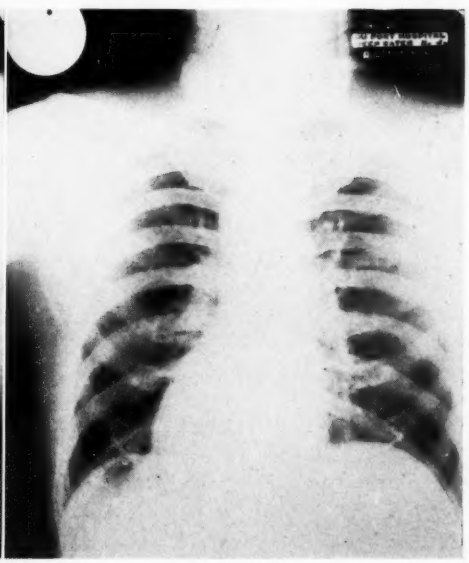

Fig. 22.

operation is run as a closed system, there have been many operating difficulties, particularly in the manufacture of hydrofluoric acid, which has been exceedingly difficult to hold in any system. The fumes in this operation have been severe. It has been only within the past year that we have considered the employment of men with glasses, since the hydrofluoric acid fumes would etch glasses in a short time. The windows in the building become frosted shortly after installation. There

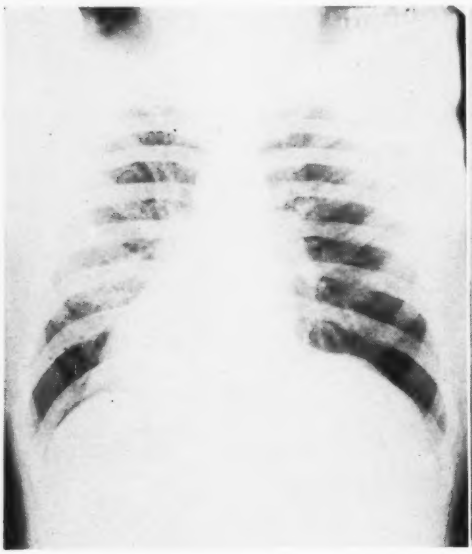

Fig. 23.

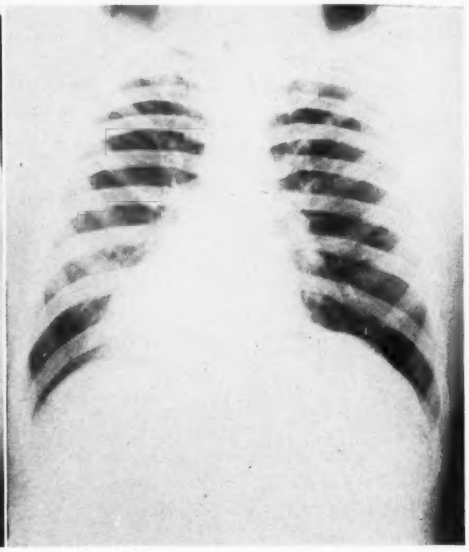

Fig. 24.

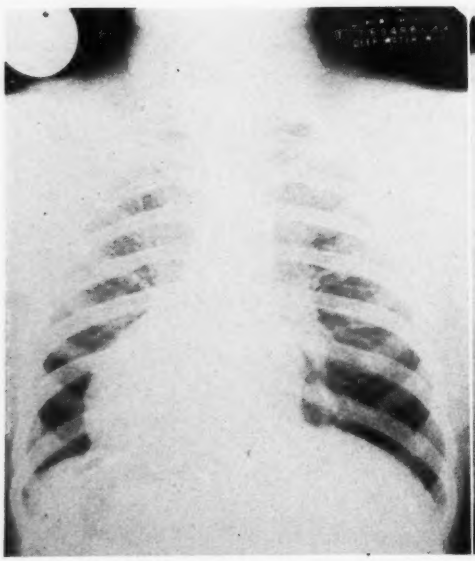

Fig. 25.

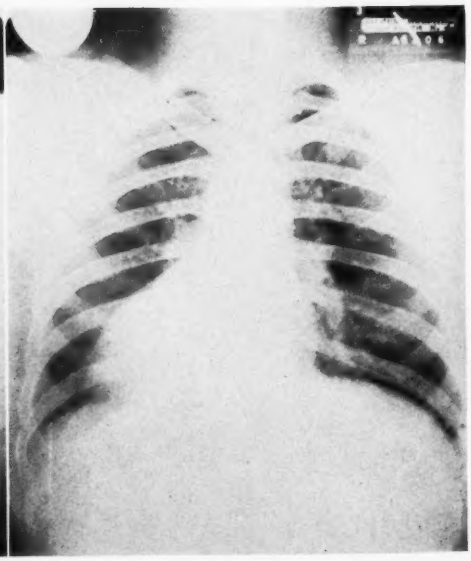

Fig. 26.

have been times when these windows have become weakened from etching and severe winds would break the glass from the frame. More recently, the operation has been perfected to such an extent that one can now spend many hours in the building without the least sign of glass etching. During the early stages of development operators and mechanics working in this department were treated for small burns due to hydrofluoric acid. These varied from first- to third-degree burns and rarely

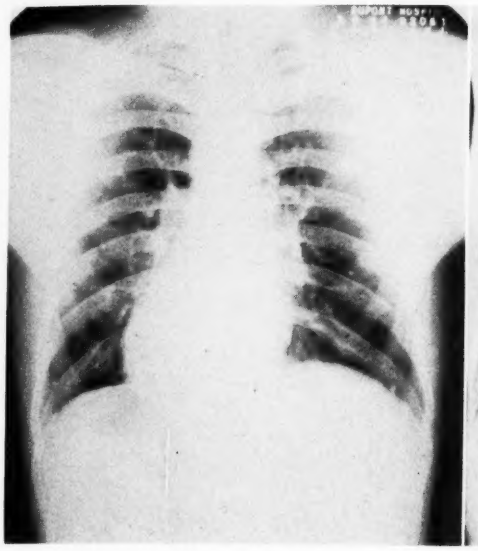

Fig. 27.

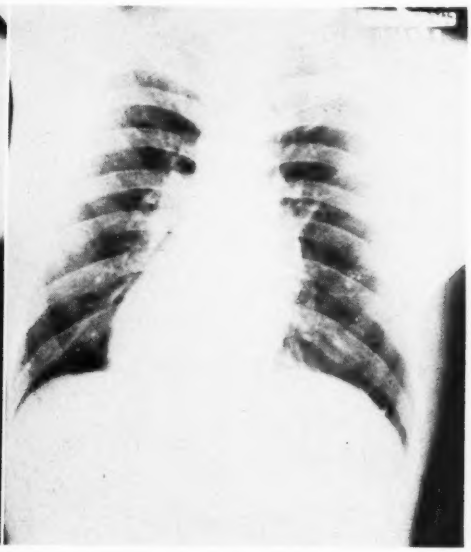

Fig. 28.

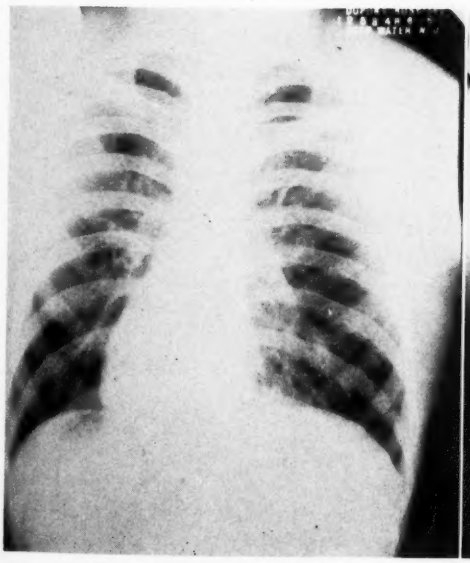

Fig. 29.

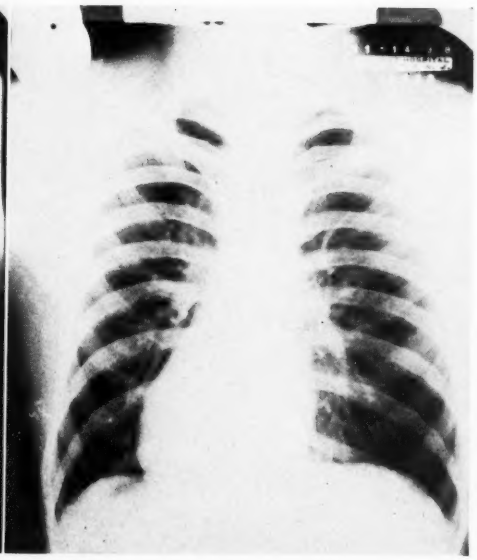

Fig. 30.

have there been cases of inflammation of the upper respiratory passages on severe exposure.

We quote these details in order to point out that exposure occurs in all of these groups even though we consider that the operating plant is a modern plant and even though every possible precaution is taken to prevent injury to those men employed in the manufacture of these products.

J. A., No. 962, male, 48 years of age. He has had 13 years' service in the

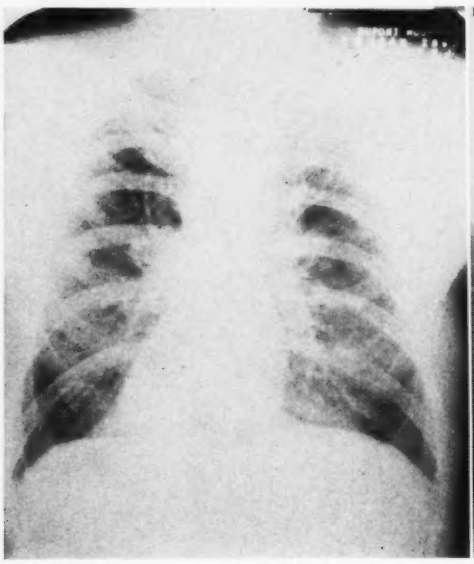

Fig. 31.

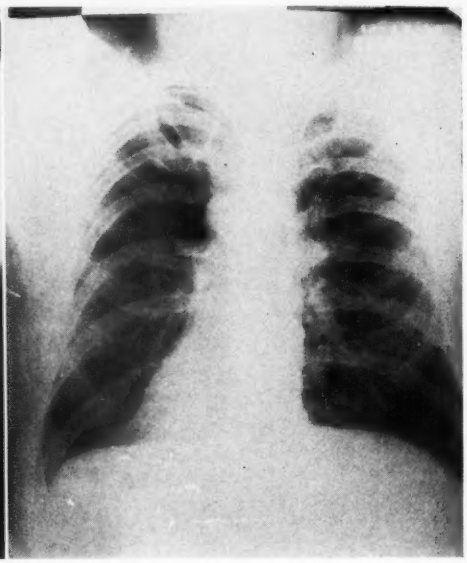

Fig. 32.

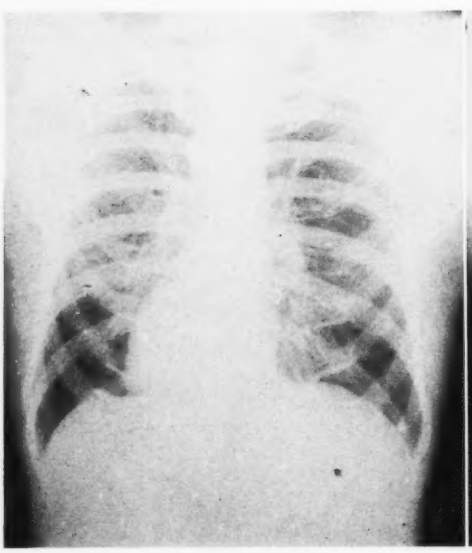

Fig. 33.

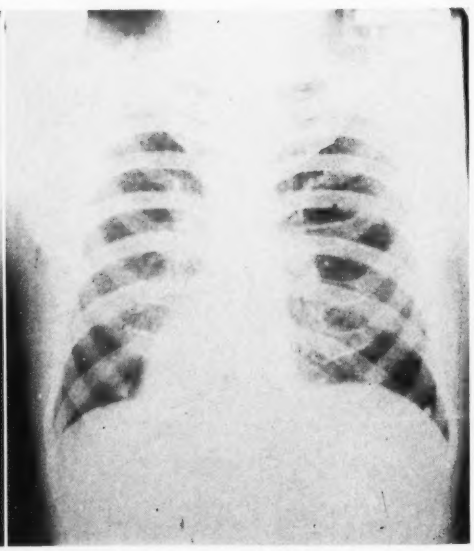

Fig. 34.

industry with six years in this area. During the past five years he has had six attacks of cold. He has had two exposures to hydrofluoric acid fumes and four instances of minor burns with hydrofluoric acid. As can be seen, the lung-fields show no increased fibrosis in the 1938 film over that demonstrated in 1933 (Figs. 21 and 22).

E. B., No. 947, male, 38 years of age. He has had four years' service in the industry, all in this area. This man has had numerous respiratory infections and three admissions for chlorine fume exposure. However, as can be seen, there is practically no change in the lung-field in this four-year period (Figs. 23 and 24).

L. B., No. 980, male, 26 years of age. He has had ten years' service in the industry and five years' service in this area. He gives a history of two attacks of upper respiratory infection in the past five years, was treated once for hydrofluoric acid burns, and twice for hydrofluoric acid fume exposure. The x-ray films (Figs. 25 and 26) do not demonstrate evidence of increased fibrosis in this period.

E. E., No. 968, male, 27 years of age. He has had four years' service in the industry, all in this area. He gives a history of six respiratory infections during the past four years, was treated twice for fume exposure. As the x-ray examination (Figs. 27 and 28) indicates, there is no increased fibrosis during this four-year period.

G. S., No. 958, male, 27 years of age, has had eight years' service in the industry and five years' service in the kinetic chemicals area. He has been treated on two occasions for fume exposure and once for a chemical burn. He gives a history during the past five years of one attack of respiratory infection. However, his x-ray films (Figs. 29 and 30) demonstrate there is no increased fibrosis. As a matter of fact, the 1938 film shows improvement over the one taken in 1934.

H. V., No. 963, male, 56 years of age. He has had nineteen years' service in the industry and seven years in this area. While this man had evidence of healed tuberculosis in the right apex, as can be seen, there is no change in this condition during the four-year period (Figs. 31 and 32).

The fourth group consists of those men who have had exposures to phosgene, phosphorus oxychloride, and phosphorus

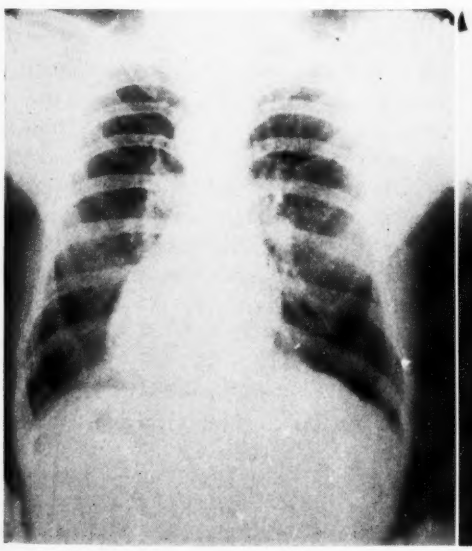

Fig. 35.

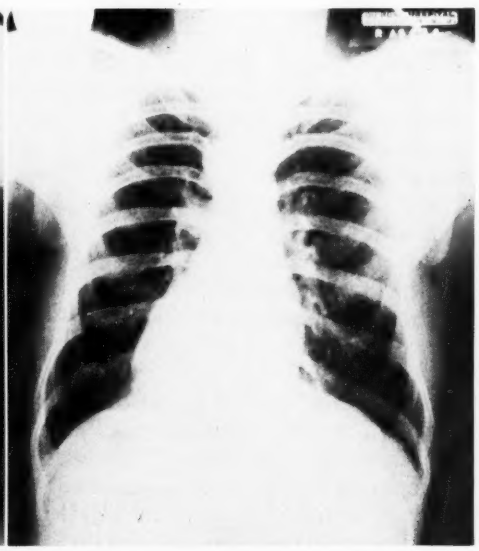

Fig. 36.

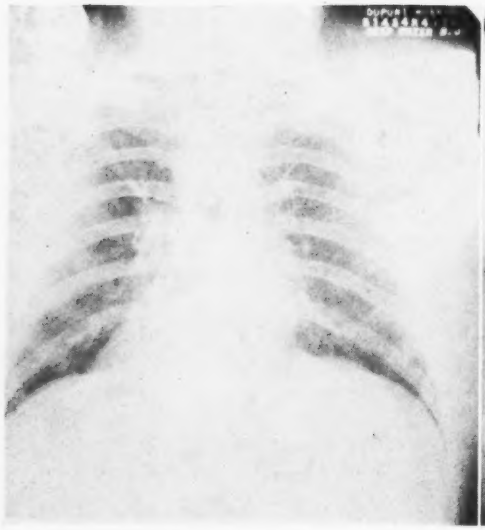

Fig. 37.

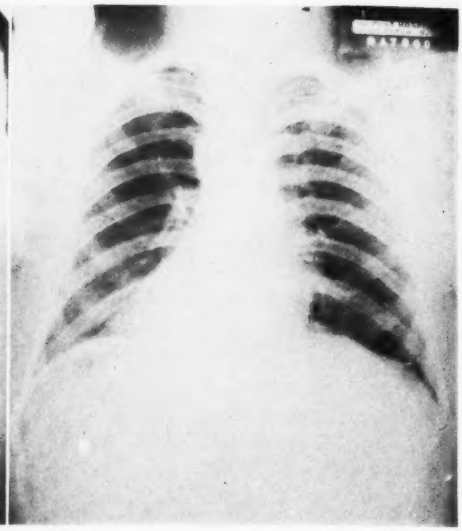

Fig. 38.

trichloride. The total number of men under observation in this group was 41. The average age of the group is 39.7 years; the average service in the industry is 10.5 years, and the average service in the area is 8.4 years.

Phosgene, as you all know, was used as a war gas. The formula for this gas is $COCl_2$ which, upon contact with moisture, breaks down to form hydrochloric acid and carbon dioxide. We, of course, are making no attempt to discuss the acute effects of any of these substances and are making no attempt to discuss the toxicologic effects in severe concentrations.

These gases also are handled in a closed system and we are reasonably certain that severe acute exposures do not occur. However, we are also reasonably certain that there are men who have had exposure to low-grade concentrations of these substances.

F. B., No. 520, male, 49 years of age. He has had fifteen years' service in the industry in this area. During the past five years, according to his history, he has had one respiratory infection. As is demonstrated by the films (Figs. 33 and 34), there is no change and, if anything, slight improvement in the lung condition.

C. W. G., No. 557, male, 44 years of age. He has been employed in the industry for 23 years and in this area for 17 years. An analysis of his illness record shows no history of respiratory infection. There is no change in the lung-field as demonstrated in the x-ray examinations between 1933 and 1938 (Figs. 35 and 36).

B. L., No. 582, male, 37 years of age. He has had nine years' service in the industry, all in this area. He has had three exposures to fumes: one to phosgene and two to a nitro-body chemical, namely, para-nitro-benzoyl-chloride. He also gives a history of two respiratory infections in the past five years. As is clearly seen in these films (Figs. 37 and 38), if anything, there is improvement in the generalized fibrosis.

T. M., No. 508, male, 45 years of age, has been employed in the industry for 19 years and in the area for 12 years. There is a history of three upper respiratory infections during the past five years. However, as the films (Figs. 39 and 40) illustrate, there is no change as demonstrated in the 1938 film over that shown in the 1933 film.

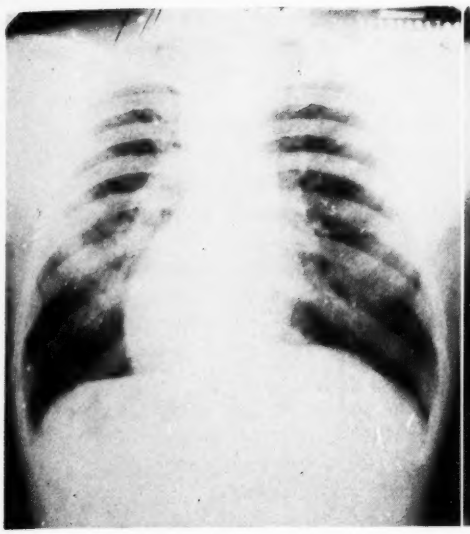

Fig. 39.

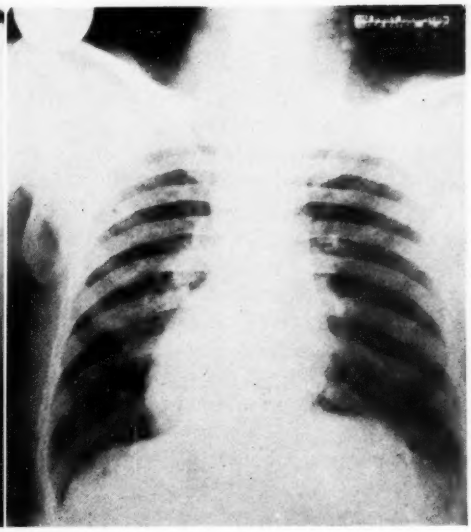

Fig. 40.

DISCUSSION

For the past five years a program has been carried out to determine the effects of low concentrations of various gases upon the human lung, namely, hydrofluoric acid, chlorine, hydrochloric acid, sulfur dioxide and sulfur trioxide, phosgene, phosphorus oxychloride, and phosphorus trichloride.

Above we have demonstrated serial x-ray examinations upon men exposed to these substances for the past five years. We have shown that, upon admission to these operations, these men have various changes in the lung tissue as evidenced by fibrosis and in some instances by calcification and fibrosis indicating healed tuberculosis. It is my opinion that in all of these cases the x-ray films show no visible evidence indicating lung changes. Our present knowledge indicates that exposures to the gases discussed above have not materially affected the lung tissue.

In addition to the x-ray studies we have discussed above, the men exposed to these various gases have had a clinical examination every three months. At the same time we have been able to follow the non-company illness picture on these individuals through the administration of an insurance plan. We can state that the incidence of pulmonary infection in these groups is no greater than that for other plant employees. There is no higher death rate from pneumonia and other pulmonary infections in this group than that recorded for the other plant employees. During this same period we can state that observations of serial x-ray films made upon employees in other groups than those discussed above show a similar appearance in the lung-fields. The average age of the men in this plant is 39.25 and the average service is 8.3 years. The total number of employees is 3,798.

This work will be continued and reviewed, since five years seem to us too short a period upon which to base emphatic conclusions. However, we do feel reasonably sure that with the present method of operation the men studied have no serious effects as the result of the exposures to which they have been subjected.

DISCUSSION OF SYMPOSIUM ON INDUSTRIAL DISEASES

ARIAL W. GEORGE, M.D. (Boston): I will start off with the lantern slides. I am

showing only a few lantern slides in this collection because from our point of view, at least, the pathology as we see it in the x-ray in this industry is uniform in the various individuals.

I want to emphasize that what I am going to say, from our experience, may not agree with those who have had considerable experience with asbestosis in other industries. I think that anyone who takes up the study of asbestos in industry should be very cautious as to the type of manufacture of the product, as the methods of manufacture and the composition of the asbestos differ widely.

(Dr. George showed slides, which he described.)

HOWARD P. DOUB, M.D. (Detroit, Mich.): I think that Dr. Evans has pretty conclusively shown us that, in chemical plants, where manufacturing processes are under careful control and supervision, it is a relatively safe procedure to work around these gases. This, however, is not always true in other types of manufacture, and I reported before this Society some years ago several cases of lung pathology that had come under my observation.

As I remember, at that time there were two cases that came from automobile radiator manufacturing plants in which the men received their injury while immersing metal in a container filled with acid—sulphuric acid, I believe. These cases showed a very extensive bronchopneumonia throughout both lungs. One of these patients recovered and one died.

On another occasion we saw a case of a janitor in an apartment house who had placed in a toilet a large quantity of some material which has the property of cleaning out stopped-up pipes. Apparently this was a highly concentrated solution and before he was able to get out of the closed room he became suffocated or partly so. He was brought into the hospital with a severe bronchopneumonia and died shortly afterward.

Since that time, we have had at least one case of lung damage due to gas escaping from one of the home refrigerating outfits, in which the patient developed one of the most extensive cases of bronchiectasis in the bases of both lungs that I have seen.

So that, while it is true that, as Dr. Evans has shown, it is possible to protect workmen against the chronic effects of these gases, we still do have the possible deleterious effects that come from these acute accidents.

THE ECONOMIC FEATURES OF X-RAY PROTECTION[1]

By LAURISTON S. TAYLOR, National Bureau of Standards, *Washington, D. C.*

I.—INTRODUCTION

PROTECTION against undesired exposure to x-rays or the gamma rays from radium can be had, but for economy and convenience it is desirable to analyze closely, with certain fundamental principles in view, each particular problem. Basic rules for x-ray and radium protection have been promulgated by the International Commission on X-ray and Radium Protection and published in numerous journals. More detailed rules, prepared in this country, are available in N.B.S. Handbook 20 (X-ray Protection)[2] and N.B.S. Handbook 23 (Radium Protection).[2] Reference to these is recommended before planning new x-ray installation.

The handbook on x-ray protection gives the rules for maximum protection; if followed strictly, any errors will be on the safe side, though not necessarily the most economical one. We give, in these discussions, certain qualifications which may permit a more economical disposition of protective barriers and devices. At the same time a number of miscellaneous points requiring special emphasis are considered.

II.—TOLERANCE DOSE

The so-called "tolerance dose" is the total x-ray energy that a person may receive continuously without suffering any damage to the blood or reproductive organs. This is expressed best in roentgens or in terms of an erythema dose.

The tolerance dose recommended by the International Protection Commission is taken as a seven-hour daily exposure at a dosage rate not exceeding 10^{-5} roentgens per second. This is roughly 10^4 times the dosage rate of cosmic radiation. It is argued by the geneticists, based largely on the work of Mueller (3), that this is ten times the safe dosage; or, in other words, the tolerance dosage rate should not exceed 10^{-5} r/sec. Their figure is based on the elimination of any second-generation genetic effects, whereas the accepted figure of 10^{-5} r/sec. is based on the effect upon the recipient of the radiation only. As may be seen below, the radiation dosage rate may be reduced from 10^{-5} to 10^{-6} r/sec. by the addition of, roughly, 30 per cent more lead in a given protective barrier. However, since the value of 10^{-5} r/sec. is the present accepted tolerance dosage rate, all of our calculations will be based on this figure, and a discussion of the relative merits of the two values will not be entered into.

Although genetic effects were not a consideration during the preparation of the international safety recommendations, it is possible that such a wide margin of safety has been provided that they have hitherto successfully protected against genetic mutations.

III.—LEAD PROTECTIVE BARRIERS

Since lead has the highest atomic number of any material readily available and easily worked, it is generally used for protective barriers and the protective value of other materials is referred to lead as a base.

Figure 1 gives a set of lead absorption curves in the x-ray excitation range of 200–400 kv. produced with a Villard rectifier and having an initial filtration of 1 mm. Cu + 1 mm. Al (hence fairly hard radiation).[3] Starting with a relative dosage

[1] Accepted for publication in April, 1939.

[2] These can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a cost of 10 cents each (stamps not accepted), mailed free.

[3] The lead thicknesses required at a given voltage will be slightly greater for constant potential excitation.

TABLE I.—MASS IN POUNDS PER SQ. FT. OF LEAD BARRIER FOR ADEQUATE PROTECTION[4]

1	2	3
Potential (kv.)	Recommended Minimum Lead Thickness (mm.)	Weight of Barrier (lb./ft.^{2})
75	1.0	2.4
100	1.5	3.5
150	2.5	5.9
200	4.0	9.5
225	5.0	14
300	9.0	21
400	15.0	35
500	22.0	52
600	34.0	80

[4] Recommendations of International Commission on X-ray and Radium Protection (1937).

rate of 10^4, the absorption measurements for the several voltages are carried out until the dosage rate has been reduced to unity.

Table I gives the thickness of lead necessary for adequate protection as prescribed by the International Commission on X-ray and Radium Protection (4). It is obvious that the figures can apply only to an incident beam of one given dosage rate at a definite distance from a given x-ray tube. These factors have never been stated in the recommendations, though they have been the subject of numerous separate publications. Hermann and Jaeger (5) have presented perhaps the best study of this phase of protection and their work forms the basis of our discussion.

Referring to Table I, it is seen that 4 mm. of lead is required for 200 kv. protection. In Figure 1 it is found that 4 mm. of lead reduces the dosage rate to about two or to $^2/_{10,000}$ th of the incident value. Thus if we assume that the transmitted dosage rate is just 10^{-5} r/sec., it follows from Figure 1 that the incident dosage rate will have been 0.05 r/sec., or 3 r/min. If we next assume a somewhat arbitrary average tube output of, say, 27 r/min. measured at 50 cm. from the target, it is seen that the dosage rate of 3 r/min. will be obtained at a position about 150 cm. from the target—the diminution in dosage rate being governed by the inverse square law.

The protective thicknesses above 200 kv. given in Table I are based on Hermann and Jaeger's work; they are self-consistent in that they all give the thickness of lead required to reduce the beam produced at any given voltage by the same amount as does 4 mm. at 200 kv. The values below 200 kv. have been found, by van der Tuuk and Boldingh (6) and by Glocker and Reuss

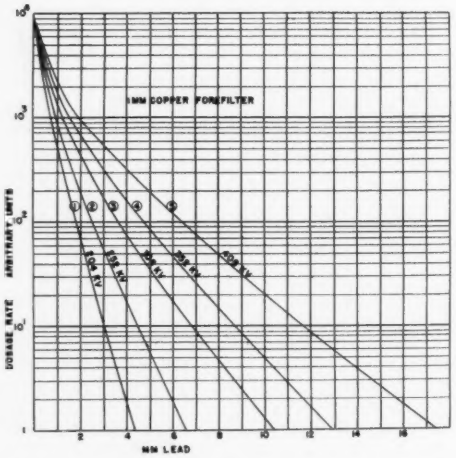

Fig. 1.

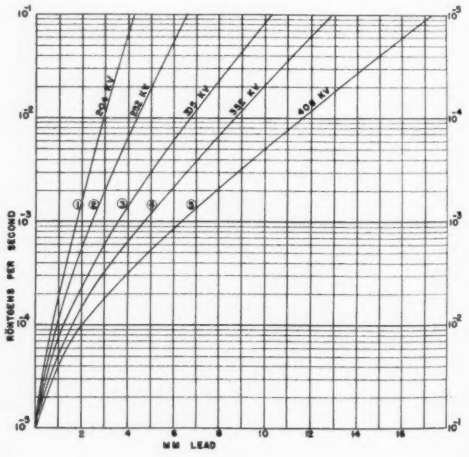

Fig. 2.

Fig. 1. X-ray absorption in lead (1 mm. Cu + 1 mm. Al forefilter). (From Hermann and Jaeger.)
Fig. 2. Dosage rate which will be reduced to the value of 10^{-5} r/sec. by absorption in the lead thicknesses given in the abscissæ (1 mm. Cu forefilter). (From Hermann and Jaeger.)

(7), to do likewise. *It is thus seen that the internationally accepted protective lead thicknesses all apply, under average dosage rate conditions, to a point 150 cm. from the target.* To simplify the examples given below we will use an average incident value of 6 r/m. (or 0.1 r/sec.) at a distance of 100 cm. from the target (corresponding to 24 r/m. at 50 cm. instead of 27 r/m.), which will introduce only a slight difference from the figure derived from the international recommendations.

To simplify the calculation of lead thicknesses for different incident dosage rates (as affected by target distance and tube output), Hermann and Jaeger (5) have replotted their data, Figure 2, to show directly the amount of lead which must be inserted in a given beam to reduce the transmitted dosage rate to 10^{-5} r/sec. For example, suppose we take the case of an incident beam at 204 kv. and a dosage rate of 0.1 r/sec. Referring to Curve 1 it is seen that 4.2 mm. of lead is required to reduce the dosage rate to the tolerance value of 10^{-5} r/sec. This is seen to be in agreement with the discussion above for the average conditions at 100 cm. If, on the other hand, it is desired to reach the safe tolerance dose after passing through a lead barrier located at a distance of 4 meters from the tube, the incident dosage rate on the lead barrier is then reduced by inverse square law to $^1/_{16} \times 0.1$ r/sec. = 0.0063 r/sec. = 6.3×10^{-3} r/sec. Again on Curve 1, the point 6.3×10^{-3} r/sec. corresponds to a required lead thickness of 2.7 mm. to reduce the transmitted radiation to 10^{-5} r/sec. If, instead of the average output of 0.1 r/sec., the output is, say, 0.033 r/sec., then the dosage rate at 4 meters would be reduced to $0.033/0.1 \times 6.3 \times 10^{-3}$ r/sec. = 2.1×10^{-3} r/sec.; for which the curve would show a required thickness of 2.2 mm. of lead to reduce the radiation to the tolerance value. It is seen that in this particular voltage range the difference between 2.7 and 2.2 mm. of lead is splitting hairs and that obviously the safe practice is to use the higher figure. Since the economy is slight it would probably be best to use simply a lead thickness of the nearest commercially available value above the higher figure.

TABLE II.—COSTS OF LEAD WALLS

Kv.	Lbs./Ft.²	$/Ft.²	Installed Unfin.*	Installed Fin.†
100	3.5	0.35	0.85	$1.20
200	9.5	0.95	1.45	1.80
300	21	2.10	2.70	3.05
400	35	3.50	4.10	4.50
500	52	5.20	6.00	6.50
600	80	8.00	9.00	9.50

* Lead fastened to furring on terra-cotta wall.
† Lead covered with lath and plaster.

At the higher voltages, however, real economies may be effected by careful consideration of the distance and output factors. Let us take the same condition at 408 kv., and refer to Curve 5, Figure 2. For an incident dosage rate of 0.1 r/sec. at 1 meter, a lead thickness of about 17 mm. is necessary to reduce the beam to the tolerance value. At 4 meters the incident dosage rate is again 6.3×10^{-3} r/sec. and the required protective thickness is seen to be only 10.5 mm., or a reduction of 35 per cent. If again the tube output at 100 cm. is reduced from 0.1 to 0.033 r/sec., the incident dosage rate at 4 meters is as before 2.1×10^{-3} r/sec. and the corresponding protective thickness is 8 mm. of lead, or a reduction of 47 per cent. It is thus clear that in the higher voltage ranges very considerable economies may be effected by considering all of the conditions involved in a particular installation.

Use of Hermann and Jaeger's curves in the manner just described applies only to conditions in which the initial reduction in x-ray dosage rate is due to scattering from main beam, tube distance, changed tube output, etc., and is unaccompanied by a hardening of the radiation. In cases in which a decrease in dosage rate is caused by filtering, and hence is accompanied by hardening, the necessary lead thicknesses must be determined, beginning at the other end of the curve and using the inverted scale of dosage rates indicated at the right of Figure 2.

To give an example, suppose we wish to compute the protection necessary in a wall

2 meters away from a lead-covered 400 kv. tube enclosure, where this lead is sufficient to reduce the dosage rate to 10^{-3} r/sec. at a distance of 1 meter from the enclosure. In this case the radiation is obviously harder than that in the unfiltered beam. The inverse square law will give, at 2 meters, an intensity of $(1^2/2^2) \times 10^{-3}$ r/sec. $= 2.5 \times 10^{-4}$ r/sec. Using the dosage rates indicated at the right of Figure 2, it is seen that on the 400 kv. curve to reduce the dosage rate from 2.5×10^{-4} to 10^{-5} will require 17.7 − 10.4 mm., or 7.3 mm. of lead. Had the original radiation been unfiltered, the lead required for protection would have been figured from the lefthand set of dosage rates and would be 3.5 mm.

In Table II are given the weights in pounds per square foot of different lead thicknesses; the cost per square foot at an average price of 10 cents per pound, and also an estimate of the installation costs.

The figures for installation are, of course, very rough and include the supporting partition of hollow tile or brick with the necessary furring to support the lead. The cost of finishing the plaster, etc., is about the same for all thicknesses. For protection at the lower voltages the cost of the supporting partition is comparable with that of the lead, while for protection at the higher voltages the cost of the lead is predominant.[5]

IV.—OTHER PROTECTIVE MATERIALS

Because of the high cost of lead protection, use of other materials, such as concrete or brick, has been resorted to with some success. Also, concretes "loaded" with barium sand, iron filings, or iron ore have been used. However, it is important to emphasize that a lead barrier will provide the lightest installation per given degree of protection (within the voltage range of 50–600 kv.). Any of

[5] The installation costs above 300 kv. are difficult to estimate and are probably low. It is quite likely that for weights above 20 lbs./ft.^{2} a special steel frame or concrete wall construction would be required for support of the lead necessary at the higher voltages. For a ceiling or floor, the lead may be simply laid on the floor and then covered with some suitable decking.

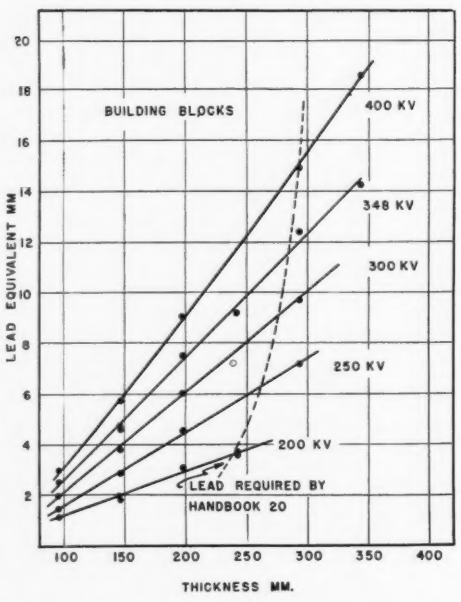

Fig. 3. Lead equivalent of poured concrete. (From Singer, Taylor, and Charlton.)

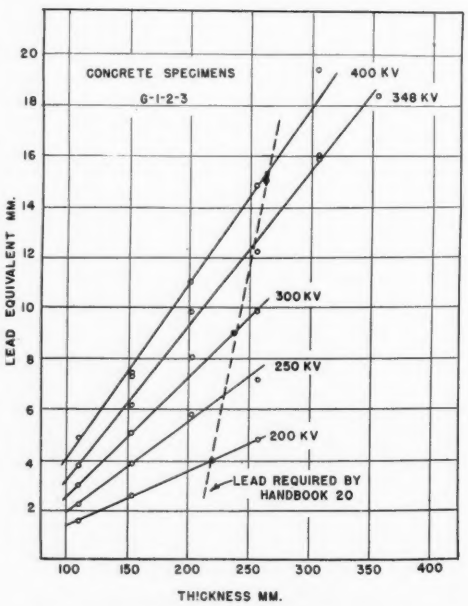

Fig. 4. Lead equivalent of concrete blocks. (From Singer, Taylor, and Charlton.)

these substitutes will be from two to twenty times heavier; but this higher load may be offset by the concrete or brick having definite structural value and thus provide economies in general building construction.

Singer (8) has shown that at a given excitation between 200 and 400 kv. the protective value of concrete is proportional to its density, and Kaye (9) has shown proportionality for other materials. We thus have the choice of making a thin wall of dense "loaded" material or a thicker wall of standard unloaded material. The relative costs depend largely upon the geographical location with respect to iron mines or barytes pits.

Figures 3 and 4 give, for poured concrete blocks, the lead equivalents at different voltages and thicknesses of material. The curves in dashed lines give, on the ordinates, the lead requirements of the International Commission.

The important feature about concrete protective barriers is that their protective efficiency, with respect to lead, increases with both voltage and thickness in the range above 200 kv. Since the thickness is the controllable factor, it is desirable to use only the full thickness necessary for a given lead equivalence. This "optimum" thickness is found to vary only slightly with voltage above 200 kv.

Table III gives the lead equivalents of concrete for the conditions imposed by the International Protection Recommendations. Column 6 shows the marked increase in the efficiency of concrete protection with increase in voltage, while Column 7 shows the decreasing weight ratio of concrete to lead. In installation, the weight ratios are smaller than shown in Column 7 since the weight of wall necessary to support the lead must be taken into consideration. It is thus strikingly evident that the desirability of employing concrete as an x-ray protective material increases with voltage.

In finished buildings, because of the difficulty of installing and filling the forms, it may not be easy or economical to install solid concrete walls, but in a new building concrete walls are easily made and form a structural member of the building. Costs of concrete walls and floors are given in Table IV.[6]

In our own laboratory, we have found that solid concrete blocks give very satisfactory protection. Here it was necessary to install three walls $13^1/_2$ ft. high; one, 26 ft. long × 6 in. thick; another, 14 ft. long × 4 in. thick, and the third, 16 ft. long × 8 in. thick. The total cost of labor and material was $410 and the average costs per square foot are given in Column 6 of this table. The blocks were made in

[6] These costs were obtained from the Supervising Architect's Office, U. S. Treasury Department.

TABLE III.—LEAD EQUIVALENTS OF CONCRETE

1	2	3	4	5	6	7
Potential (kv.)	Recommended Lead (mm.)	Concrete Equivalent (mm.)	Mass/Unit Area Lead (gm./cm.²)	Mass/Unit Area Concrete (gm./cm.²)	Thickness Concrete ÷ Thickness Lead	Mass of Concrete ÷ Mass of Lead
100	1.5	120[a]	1.7	28	80.0	16.5
200	4	220[b]	4.5	53	55.0	11.8
300	9	240[b]	10.2	57	26.7	5.6
400	15	260[b]	17.0	60	17.3	3.5
600	34	300[d]	38.4	65	8.1	1.7
1000	86[f]	...	97.5	...	...	...
Gamma	100[e]	540[c]	113.4	130	5.5	1.2
"	50	270[c]	...	...	...	...

[a] From Kaye, $\rho = 2.1$ g./c.c.
[b] From Singer, Taylor, and Charlton (8), $\rho = 2.35$.
[c] Calculated from Kaye, Binks, and Bell (9), $\rho = 2.35$.
[d] Extrapolated value from Singer, Taylor, and Charlton (8).
[e] From Kaye, Binks, and Bell (9); 100 mm. applies to 3 grams of radium at a distance of 100 cm.: 50 mm. applies to 0.25 gram of radium at a distance of 100 cm.
[f] From Dresser and Cosmon (10), recalculated to accord with International Recommendations.

TABLE IV.—COST OF CONCRETE WALLS AND FLOORS

1	2	3	4	5	6
Voltage (kv.)	Thickness (cm.)	Thickness (in.)	Cost/Ft.² Wall*	Cost/Ft.² Concrete Floor*	Cost/Ft.² Concrete Block†
100	12.0	4¾	$0.63	$0.38	$0.56
200	22.0	8½	0.72	0.47	0.65
300	24.0	9½	0.77	0.52	0.70
400	26.0	10¼	0.79	0.54	0.73
1000	(30.0)	(12)	0.84	0.59	0.80

* Installed during building construction.
† Installed in completed building.
( ) Extrapolated values.

standard block molds with cores removed and of such a dry mix that they could be easily handled after forming. All joints were filled solid with mortar and tests showed a very homogeneous wall.

Table V, Column 4, shows the lead equivalents for concrete blocks for the conditions imposed by the International Protection Recommendations. For comparison, the lead equivalents of several other materials are also given in the same table.

TABLE V.—LEAD EQUIVALENTS OF VARIOUS BUILDING MATERIALS

1	2	3	4	5	6	7
		Concrete*	Concrete Block*	Barium Concrete†		
Kv.	Lead (mm.)	ρ = 2.4 (mm.)	ρ = 2.05 (mm.)	ρ = 3.2 (mm.)	ρ = 2.7 (mm.)	Brick‡ (mm.)
75	1.0	80	85	15	...	175
150	2.5	210	220	28	52	290
200	4	220	245	60	100	430
300	9	240	275	105	150	425
400	15	260	290	140	185	450
Gamma rays‡	50	(242)	(270)	200	225	...
	100	(480)	(540)	400	450	...

* Taken from Singer, Taylor, and Charlton.
† Taken from Kaye, Binks, and Bell.
‡ For quantity of radium, see Table III.
( ) = calculated values.
ρ = density.

V.—PROTECTION AGAINST DIRECT RADIATION

Having outlined the methods of calculating the required lead protective thicknesses against direct radiation and indicated the factors involved in the choice of protective materials, we may now take up the more specific problem of protection in the treatment room. As above, the discussions can be simplified by taking as a working base a tube the output of which measured 0.1 r/sec. at 100 cm. from the target (= 24 r/m. at 50 cm.).

The calculations given above apply to the direct beam, and while it may be assumed that there is always a patient in the beam, and hence the tube output is effectively less, it is unsafe to base computations on conditions with an obstructed beam. This reservation applies, of course, to all portions of a room which may be reached by a direct beam (see N. B. S. Handbook 20, ¶ 305 and 406).

The best protection in the average therapy room may be accomplished through application of the inverse square law, for the tube is seldom closer than three or four meters to the wall which separates it from the operator. The curves in Figure 5 give the dosage rate and the required lead thickness as a function of the distance from the tube, for the 0.1 r/sec. output (at 100 cm.) at several different voltages. This figure may be used in the routine computation of the necessary protective lead thicknesses, at different distances. Particularly in a new building, it may be easier to place the operator and partition relatively far from the tube than to build a smaller but heavier partition near the tube. In cases in which the area of the partition will not be affected by its distance from the tube, the economy of moving it away is obvious. On the other hand, in cases in which concrete replaces

lead, the savings resulting from shifting the partition away from the tube are slight. Taking the 400 kv. case, it is seen that 15 mm. of lead or 26 cm. of concrete are needed for protection at 2 meters, while 10 mm. of lead or 18 cm. of concrete are needed at a distance of 5 meters (see Fig. 3). The saving in cost and weight by shifting the partition is about 30 per cent for lead; while for concrete, although the weight is also decreased by about 30 per cent, the cost is not reduced by more than 5 to 10 per cent.

Protective barriers can be applied directly to the tube itself, in which case the target-lead distance may be only 10 or 15 cm., although for a given degree of protection this requires a slightly greater thickness of lead. The amount is far smaller than that necessary for a whole partition or room. Added lead thickness applied directly to the tube lessens that required by the walls, up to the point at which the stray radiation from the tube equals the scattered radiation from the patient and other objects in the direct beam. This reduction in thickness, of course, does not apply to portions of the room reached by the main beam.

There is a real question as to how far the protection on an x-ray tube should be carried. As mentioned, in cases in which the tube shield is to replace some of the wall protection there is no advantage in increasing it beyond the point at which the radiation transmitted through it is less than the amount scattered by the patient. This is, of course, a very uncertain limitation, depending upon local treatment conditions. So far as protection to the patient alone is concerned, the tube shielding can probably be greatly reduced, since there is probably no objection to the patient receiving some 1 per cent of his treatment dose in the form of scattered radiation over his whole body. However, it is important that this scattered radiation should not "leak" out at a single localized region as, for example, where the patient is in physical contact with the tube shield. Against the condition at which the patient may

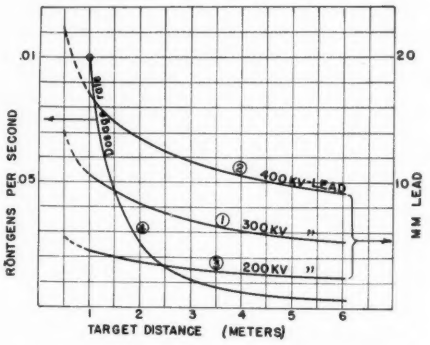

Fig. 5. Change in dosage rate (Curve 4) and corresponding protective lead thickness (Curves 1–3) as a function of distance from the x-ray tube.

come into prolonged contact with the tube shield, the lead on the shield may be built up to a degree at which the dosage rate at the surface will not exceed, say, 5 per cent of the maximum used at 50 cm. If, with the present-day flexibility of therapy tube mountings, the direct beam may strike almost any portion of the treatment room, full protection against direct radiation in accordance with the discussions above must be arranged. In such a case the tube protection may be reduced to a very low level insofar as it may affect the protection to the operator outside.

VI.—PROTECTION AGAINST SCATTERED RADIATION

Thus far the discussion has been limited primarily to protection against direct radiation, but scattered radiation is always present and must be reduced to at least the same end value as the direct. Exact directions for accomplishing this most economically are difficult to formulate because of the uncertainty in the large number of contributing conditions.

Scattering is principally from the patient and the treatment table or the floor. That from the patient varies very considerably with field area, so for computation purposes the scattering from the largest area should be taken. Treatment cones (if lead-lined) reduce thes cattering to a level substantially below that without a cone.

TABLE VI.—X-RAY SCATTERING FROM A WAX PHANTOM MEASURED AT 1 METER FROM THE CENTER OF THE INCIDENT BEAM (200 KV., 30 R/MIN. AT 50 CM.)

1	2	3	4	5
Field Size (cm.)	R/sec. at 1 m.	Percentage Ratio to Incident Beam*	Quality (H.V.L. Cu) (mm.)	Equivalent‡ Voltage (Constant) (kv.)
20 × 20	0.0011	0.22	0.42	130
10 × 15	0.00046	0.09	0.50	135
6 × 8	0.00019	0.04	0.62	160
15 × 15†	0.003	0.6	0.64	...

* Quality of incident beam, 0.72 mm. Cu (H.V.L.).
† From paper by Behnken.
‡ Very rough values.

Braestrup (11), using limiting cones, has given figures (Table VI) for the scattering from a wax phantom irradiated over different field areas with 200 kv. x-rays filtered with 1 mm. Cu + 1 mm. Al at 50 cm. focal distance and a dosage rate of 30 r/m. (= 0.5 r/sec.).

The last row in the table is taken from a paper by Behnken (12) and adjusted to conditions comparable with Braestrup's. The discrepancy between the findings of the two investigators is not surprising when one considers the number of variables in both cases. Braestrup's figure for the largest field shows that the scattering at right-angles to the beam is about 0.2 per cent of the dosage rate of the primary beam and decreases with decrease in field size. It is reasonable to expect that at lower voltages the scattering ratio will not increase, and although the amount of scattering will increase at higher voltages it will take place at a smaller angle to the direct beam, so that the scattering ratio at right-angles to the beam will probably not exceed that for 200 kv. Therefore, if we allow a somewhat generous safety factor, a scattering ratio of 1 per cent may be used as a basis for calculating the protection to be provided against the scattered radiation.

It is next seen from Braestrup's figures that the quality of the scattered radiation is substantially softer than that of the incident radiation, and under some circumstances advantage may be taken of this in computing protective thicknesses. Below 200 kv. the decrease in penetration of the scattered compared with the direct radiation is not very great, nor are very considerable lead economies to be made by any ordinary means. However, above 200 kv. the quality changes are more marked and the possible savings are greater by whatever means achieved.

The wave length of the scattered radiation at the higher voltages may be computed with sufficient accuracy for our purpose by means of Compton's simple scattering formula

$$\lambda_\theta - \lambda_0 = \Delta\lambda = 0.0243(1 - \cos\theta)$$

in which λ_0 and λ_θ are the wave lengths of the incident and scattered radiation, respectively, and θ is the angle between the direct and scattered beam ($\cos\theta = 0$ at 90°). Table VII gives, for a number of excitation voltages, the minimum wave length of the primary beam (Col. 2) and the scattered beam (Col. 3) and the voltage equivalent to the minimum wave length of the scattered radiation (Col. 4). The possible effect of pair production is neglected.

It is at once apparent that the relative softening (lowering of the equivalent excitation voltage) of the radiation by scattering is appreciable at 200 kv. and increases very rapidly above 200 kv. At 510 kv., for example, the scattered radiation has a quality equivalent to only half that voltage, while at 1,000 kv. the equivalent voltage of the 90° scattered beam is only a third that of the direct beam. When computing, therefore, the lead barriers for scattered radiation, the absorption of the lead is to be taken from the curves at the voltage corresponding to that of the scattered radiation and not the direct radiation.

Two examples will illustrate the combined uses of Tables VI and VII.

Case 1. Two hundred kv., 0.1 r/sec. at 1 m.; compute the thickness of lead wall 4 meters from patient in direction at right-angle to beam.

From Section IV: dosage rate of scattered beam at 1 meter from patient = 1% × 0.1 r/sec. = 10^{-3} r/sec.

From the inverse square law: dosage rate at wall = $^1/_4{}^2 \times 10^{-3} = 6.3 \times 10^{-5}$ r/sec.

Using the 200 kv. lead absorption curve (Fig. 2), it is found that a further thickness of less than 0.6 mm. of lead is required to reduce the dosage rate to the tolerance value on the other side of the wall.

Case 2. Four hundred kv., 0.1 r/sec. at 1 meter; compute the necessary thickness of lead 4 meters from patient in direction at right-angles to beam.

Dosage rate of scattered beam at 1 meter from patient = $1\% \times 0.1$ r/sec. = 10^{-3} r/sec.

Dosage rate at wall = $^1/_4{}^2 \times 10^{-3} = 6.3 \times 10^{-5}$ r/sec.

The effective voltage of scattered radiation is 250 kv. From Figure 2 it is found that 0.7 mm. of lead is required to reduce the dosage rate to the tolerance value of 10^{-5} r/sec. on the other side of the wall. (Using the 400 kv. curve would give a value 1.5 mm. for the lead required.)

In both cases it is seen that, compared with direct radiation, very great reductions in the wall thickness for adequate protection against scattered radiation may be made. In the 200 kv. case the thickness of lead as compared with that necessary for the direct beam is 17 per cent, and for the 400 kv. case, 8 per cent. It has been assumed in these cases that stray radiation through the tube shields was reduced to a level substantially below that of the radiation scattered by the patient.

The above discussion has dealt only with the modified scattered radiation calculated by Compton's formula. There will, of course, be a small component of unmodified radiation scattered at 90° to the direct beam. By consideration of the form factor in the higher voltage region (400–1,000 kv.), Bethe has calculated the unmodified electron scattering from the K shells (13). He finds this to be, for lead, less than 5×10^{-5} times that of the direct beam, and, for concrete, less than 5×10^{-9}

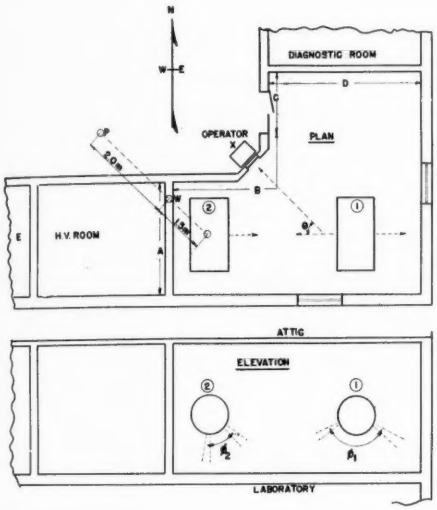

Fig. 6. Typical deep therapy room layout.

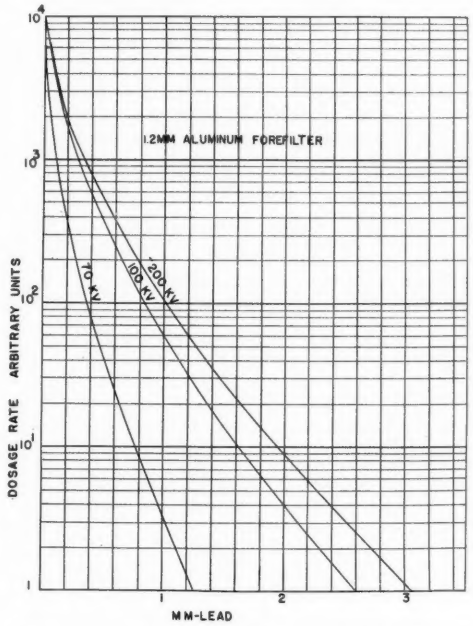

Fig. 7. X-ray absorption in lead at low excitation voltages.

TABLE VII.—MINIMUM WAVE LENGTH AND EQUIVALENT VOLTAGE OF X-RAYS SCATTERED AT 90°

1 Excitation Voltage (kv.)	2 λ Min. (Primary) (Å.)	3 λ Min. (Scattered) (Å.)	4 Equivalent Voltage (kv.)
100	0.1234	0.1477	84
200	0.0617	0.0860	144
300	0.0412	0.0655	189
400	0.0309	0.0552	222
510	0.0243	0.0486	255
1000	0.0123	0.0365	340
1500	0.0081	0.0324	380

times the direct beam. For body tissue, the fraction will be even smaller. Contributions from the L and M shells and nuclear scattering will all be less than the values above. Thus, considering the extreme case of scattering by lead, if we start with an incident dosage rate of 0.1 r/sec. the dosage rate of the unmodified radiation at 90° will be less than 10^{-6} r/sec. Since this is already below the tolerance dose no additional protection need be added therefor.

Protective barriers close to the target have particular value in the case of supervoltage radiation—above 400 kv.—where immense quantities of protective material would be required if applied merely to the walls of a room. At excitations in the region of 1,000 kv. the target is usually at the end of a tube which has a length from five to ten times its diameter. By surrounding the target tube with some three inches of lead (the required amounts are not yet known exactly), the escape of radiation is limited to the useful treatment beam and a useless beam directed back along the axis of the x-ray tube. By giving some consideration to the direction of these beams it is possible to design an installation in which all radiation striking a protective wall will have been scattered one or more times through a total angle of at least 90°. From Table VII the scattered radiation is thereby reduced to a hardness which requires relatively less protection.

A practice has grown up in this country of using protective barriers extending only seven feet up from the floor instead of to the ceiling. In some cases this provides adequate protection but the practice is dangerous and should be condemned, because of radiation scattered by the air and ceiling to the outside of the partition where the operator is located. Braestrup (11) has studied several such installations and finds that the scattering behind a seven-foot partition in therapy installations is ten to twenty times as great as behind the same partition when extended to the ceiling.

VII.—LOCATING X-RAY TUBES IN TREATMENT ROOMS

In cases in which limiting the flexibility of the tube mounting does not interfere too greatly with the treatment flexibility, the room protection may usually be simplified by careful choice of the tube position, tube mounting, and possible angulation of the beam. It is not feasible to attempt to discuss all the possible conditions under this head, nor does it seem possible at the moment to set up any simple rules to cover cases in general. Braestrup (11) has discussed a group of treatment rooms with respect to their protection, and reference should be made to his paper. We will give simply an analysis of a typical problem presented to us for solution recently.

The question involved the installation of a 400 kv., 12 ma. equipment in a building already constructed. The equipment was to be placed in an outside corner room because outside walls require no protection.[7] The selected disposition of equipment and occupancy is shown in Figure 6. The position selected for the operator was the only feasible one. The room below required protection at the floor for full-time occupancy. The ceiling, however, was next to the roof; consequently, it and the outside walls needed no protection. The diagnostic room was assumed to be occupied by staff personnel 20 per cent of

[7] This is not always the case; consequently, caution must be exercised when considering the protection on outside walls.

the seven-hour day, permitting five times the adopted tolerance dose for continuous exposure.[8] We have a choice of positions, 1 and 2, for the x-ray tube; in which in either case it is in a lead-lined tank. In Position 1 the direct beam can be swept through an angle φ_1, in the vertical east-west plane, and in Position 2, through the more restricted angle φ_2. With the x-ray tube located in Position 1 there is then the possibility of pointing the direct beam in the general direction of the operator. Under this condition the angle θ between the direct and scattered beam toward the operator is only about 45°, in which the scattered radiation would be substantially more intense than given in Table VI. In this case a value of 10 per cent of the main beam may be assumed. The hardness of the scattered radiation is also greater than shown in Table VII because the angle between the direct and scattered beam is 45° instead of 90°. To err on the safe side, lead absorption values are taken as for the direct beam, instead of the scattered, from the 400 kv. curve in Figure 2. The distance between Partition B and scattering body is about eight feet (2.5 meters). Starting with the tube output of 0.05 r/sec. at 100 cm., the scattered radiation, already assumed as 10 per cent at 1 meter, will be about 0.10×0.05 r/sec. $= 0.005$ r/sec. At the Partition B the dosage rate will be $1/(2.5)^2 \times 0.005$ r/sec. $= 8 \times 10^{-4}$ r/sec. From the 400 kv. curve in Figure 1 it is found that to reduce the dosage rate at this point to the tolerance value, the lead partition must be about 6 mm. thick (or 15 cm. of concrete). Had allowance been made for the softening in quality of the scattered radiation, the lead partition might be fixed at 3 mm.

As a rule it is undesirable to permit the direct beam to point even in the general direction of the operator. For that reason, Position 2 for the tube was considered. Here the tube and patient are both nearer to the operator (2 meters) but the direct beam cannot possibly point in a direction closer than 90° to the operator. Calculating the scattering as before, we have 1 per cent of 0.05 r/sec. = 0.0005 r/sec. at 1 meter at right-angles to the direct beam, and $1/(2)^2 \times 0.0005$ r/sec. $= 1.2 \times 10^{-4}$ r/sec. as the dosage rate at the position of the operator. Using the 250 kv. curve in Figure 2, it is seen that the required lead Barrier B should be 1.0 mm. thick (or, not making allowance for the change in quality by scattering and using the 400 kv. curve, 2.2 mm. thick).

It is seen, therefore, that, with 2.2 mm. of lead instead of 6 mm., there is a distinct gain in placing the tube at Position 2 instead of at Position 1, not to mention the added safety factor arising from the impossibility of the beam being directed toward the operator. The solution here assumes adequate protection in the tube shield; if this does not obtain the protection on Partition B should be increased correspondingly. In shifting from Position 1 to 2, there is but a slight decrease in the required protection on Partition D. To calculate this protection we may again start with a scattered dosage rate (at 1 meter) of 0.0005 r/sec. and make an inverse square law adjustment which gives the dosage rate at the distance 3.3 meters of the Wall D. We derive $1^2/(3.3)^2 \times 0.0005$ r/sec. $= 5 \times 10^{-5}$ r/sec. at D. On the 400 kv. curve of Figure 2 this calls for 1.2 mm. of lead, or for the softer radiation on the 250 kv. curve, 0.6 mm. of lead.

The Doors C should have about the same amount of lead as the Partition B (2.2 mm.), since the operator is located nearby.

The protection on the west might be divided merely between Walls A and F because Wall E serves another deep therapy room and is 3.5 meters away. Assuming a somewhat arbitrary position for the working personnel such as P, 3.5 meters away from the tube, and also that all the protection to this position be applied on Wall A alone, the scattering, as above, from the

[8] It may be the safest practice to assume that a room occupied at all is occupied full time, but we give the other case to indicate how it may enter the computations.

TABLE VIII.—LEAD EQUIVALENTS OF PROTECTIVE MATERIALS AT LOW VOLTAGES

1	2	3	4	5
		Lead Equivalents		
Excitation Voltage (kv.)	Recommended Lead (mm.)	Ba Plaster* = 3.5 G./C.c. (mm.)	Concrete = 2.1 G./C.c. (mm.)	Brick = 1.5 G./C.c. (mm.)
50	0.5	4	50	80
100	1.5	7	100	200
150	2.5	24	175	400

* Two parts coarse $BaSO_4$, 2 parts fine $BaSO_4$, 1 part cement.

tube at Position 2 is 5×10^{-4} r/sec. at 1 meter and hence $1^2/(1.5)^2 \times 5 \times 10^{-4}$ r/sec. $= 2.2 \times 10^{-4}$ r/sec. at the Position W of the wall. At P the permissible dosage rate is 10^{-5} r/sec., so that at Position W it can be $(3.5)^2/(1.5)^2 \times 10^{-5}$ r/sec. $= 5.5 \times 10^{-5}$ r/sec. Referring to the curve for 250 kv. in Figure 2, we find that to reduce the dosage rate from 2.2×10^{-4} to 5.5×10^{-5} an 0.8 mm. lead thickness is required. (By not considering a quality change, and, therefore, using the 400 kv. lead absorption curve, it is found that 2 mm. of lead will provide adequate protection.)

Since the beam may be assumed to be directed toward the floor the greater part of the time, and since the room below is occupied, the floor should be adequately protected with lead or its equivalent. Directly beneath the tube and extending some 2 meters to the east, the dosage rate of the direct beam (150 cm. minimum target distance) will be no more than $(0.5)^2/(1.5)^2 \times 0.05$ r/sec. $= 5.5 \times 10^{-3}$ r/sec., in a case in which 0.05 r/sec. is the dosage rate at a distance of 0.5 meter. Referring to the 400 kv. curve it is seen that 10 mm. of lead is necessary to provide adequate protection. At the 2 meter limit (target distance 2.5 m.), the dosage rate will be about $(0.5)^2/(2.5)^2 \times 0.05$ r/sec. $= 2 \times 10^{-3}$ which requires 8 mm. of lead protection. The lead could perhaps be graded in small steps, although this might introduce difficulties in making a smooth floor. As seen from Figure 3, a 25 cm. (10 inch) concrete floor would provide adequate protection.

VIII.—PROTECTION AT VOLTAGES BELOW 100 KV.

The problem of protection below 100 kv. is relatively simple and needs almost no discussion beyond that given in Handbook 20. For protection against a direct beam, lead thicknesses up to 1.5 mm. are sufficient and a 50 per cent reduction in thickness leads to no great saving. In this region protection by brick, barium plaster, etc., finds considerable application. Table VIII gives the lead equivalents for several of the common construction materials at different low voltages. These are taken from Kaye (2).

From this table it is seen that up to 100 kv. any of the materials listed will provide adequate protection without introducing constructional difficulties. A 200 mm. (8 inch) brick wall should suffice, but care must be taken to insure completely filled mortar joints. At 150 kv., about one inch barium plaster is required and difficulties may be encountered because of its weight (16.7 lb./ft.^{2} as compared with 5.9 lb./ft.^{2} for lead) and mode of application. Brick at this voltage is not desirable because of the excessive thickness required. Lead or concrete appears the more logical material.

In the diagnostic voltage range, protection to the radiologist becomes a much more serious problem than protection to the technician or occupants of adjoining rooms. The radiologist is exposed to the scattered radiation from the patient, thereby eliminating the use of walls as protective barriers. Lead rubber aprons and gloves are about the only form of protection available to him. Cilley, Leddy, and Kirklin (14) have made very exhaustive studies of the protection problem for most conditions encountered in clinical roentgenoscopy, and their original papers should be consulted. The most important conclusion derived from their studies is that exposure of the radiologist is held to a minimum by using the smallest field of irradiation commensurate with his particular task. It goes without saying

that fluoroscopic examinations should be carried out as expeditiously as possible.

IX.—PROTECTIVE TUBE ENCLOSURES

The question of how far to carry the protection as applied directly to the tube enclosure is still open. It has already been mentioned in Section V for therapy tubes and in all the preceding discussions it has been assumed that the tube enclosure is sufficient to reduce the transmitted dosage rate to a value below that scattered from the patient. However, the problem in the diagnostic voltage range is inherently different from that in the therapy range, in which we have suggested that the tube enclosure be such as to reduce the stray dosage rate to a value of about 1 per cent of the treatment beam at the position of the patient.

With fluoroscopic tubes the protection should be sufficient to reduce the transmitted radiation to a value substantially less than the scattering from the patient, when using the smallest field of irradiation. This again depends upon many variable factors, and is practically impossible of generalization. In vertical chest fluoroscopy, the patient himself serves as a partial shield to the radiologist, whereas in horizontal fluoroscopy this protection is largely lacking.

Gross (15) has made some measurements of the scattering from a patient reaching a point one meter away in a direction at right-angles to the beam, the tube being operated at 80 kv. and fully protected. With and without a cone he found the scattered dosage rate, respectively, 0.03 and 0.1 per cent of the direct beam incident on the patient at a 60 cm. skin-target distance. This is in reasonably good agreement with the percentage of scattering adopted in Section VI, so we may be justified in taking a maximum permissible dosage rate of scattering to 0.05 per cent that of the main beam. Referring to the curves in Figure 7 which give the lead absorption at low voltages it is seen that lead of about 0.9 mm. thickness around the x-ray tube would provide the necessary amount of protection to the radiologist when using 70 kv. excitation. Since, in any case, the quantities of lead involved in 75 kv. protection are not large, this should not be an excessive demand. We are not in a position at the present time to reach any final conclusions in this regard, but these figures are believed to be on the safe side.

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A PRELIMINARY REPORT OF THE EFFECT OF X-RAYS ON A TUMOR OF KNOWN GENETIC CONSTITUTION[1]

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THE effect of short wave length x-rays or gamma rays on the tissues of both plants and animals has been studied extensively since the discovery of roentgen rays and radium at the end of the last century. The attention of the workers using plant life has been devoted, first, to the determination of the rate of growth of root and stems following irradiation of either the entire seedling or some portion of the growing plant, and second, to the determination of mutative changes produced in the plant by the rays. Similarly, workers have investigated the changes produced by radiation of invertebrates both as to destructive effects leading to death and to genetic changes in the tissues of the organism. Some of this work has been of particular value in studying radiation both qualitatively and quantitatively aside from its biologic aspect, *i.e.*, these organisms have been used to supplement physical instruments in the investigation of dosage problems.

When going to higher forms of life such as the mammals, these experiments have been directed to a great extent toward the destruction of tissue, the inhibition of its growth, or alteration of function. Investigations on the effect of x-radiation on mammalian tumors, particularly those of mice, have also been directed to the ultimate dissolution of the tumor. These latter are very comprehensive in that they concern themselves with radiation applied to the whole animal, to the tumor itself *in vivo*, to the tumor *in vitro* followed by inoculation into another host, or to the tumor bed prior to transplantation. In these radiation experiments we are sometimes dealing with tumors of spontaneous origin, and, in other instances, transplantable tumors. In many cases the results obtained from radiation experiments on transplanted tumors cannot be interpreted to apply to spontaneous tumors; in other words, the results are not interchangeable.

As mentioned earlier, these investigations have been directed toward causing a regression of the tumor mass and comparatively little attention has been devoted to the effect of radiation on the genetic constitution of the tumor itself. The present paper is a preliminary report of an experiment investigating this last phase of the subject of the effect of radiation on a tumor, namely, a change in its genetic constitution. We have attempted to determine whether x-rays of high or low dosage would alter the genetic constitution of a tumor which ordinarily grows in only one of several pure strains of mice.

History of Tumor.—The tumor selected for this work was one which arose spontaneously in one animal in the dilute brown stock called *dbrB*, in 1920, which, upon microscopic examination, was diagnosed as adenocarcinoma. This tumor has been carried on for 18 years by means of successive transplants. During this time the tumor has been tested frequently and its genetic constitution has been determined from time to time. When this tumor was inoculated into members of the same strain, namely, the dilute brown *dbr* strain, there was a "take" of 100 per cent. On the other hand, when the same tumor was transplanted into mice of three other pure strains, namely, Little's C_{57} *black*, Bagg's albino, and Strong's *CBA*, the result was complete failure of tumor growth.

The genetic constitution of this tumor, *dbrB*, had been determined previous to the present experiment by inoculating fragments of the tumor into the F_1 hybrids

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[2] Part of this work was made possible by a grant from the International Cancer Research Foundation of Philadelphia.

produced by crossing the tumor-susceptible strain *dbr* with one of the above mentioned tumor-resistant strains. There was found to be 100 per cent takes in the F_1 hybrids. These hybrids were in turn mated brother to sister in order to obtain the F_2 generation. Upon inoculation and subsequent segregation of takes and non-takes, this F_2 generation showed three positives to one negative, or, in other words, it was found that this tumor, *dbrB*, has a genetic factor ratio of 3:1.

Radiation of Tumor.—Approximately one week after inoculation of a group of dilute brown mice with fragments of tumor *dbrB*, the tumors attained the size of one cubic centimeter. At this time the entire mouse was covered with a sheet of lead one-sixteenth inch in thickness in which a hole was cut large enough to expose the tumor and still protect the remainder of the body from x-ray injury. The mouse was radiated with x-rays generated at 200 kilovolts peak, filtered through 0.5 mm. of copper. This combination of voltage and filtration produced a beam of x-rays having an effective wave length of 0.16 Ångström unit. The distance from the tumor to the target was 30 cm., selected so as to decrease the time of exposure and prevent over-exposing those tissues underlying the tumor. For the high dose we delivered to the tumor a dose of from 1,200 to 1,500 r, air-scattered only, at a rate of 63.3 r per minute. This amount of radiation represents one and one-half to two human skin erythema doses, and produces a definite regression in these tumors within a week, leading to their complete destruction as shown microscopically.

Obviously, since a dose of this magnitude caused complete regression of the tumor, it was felt that a decidedly smaller dose should be used to produce genetic changes with no destruction. We were fortunate that the dose of 100 r, selected for the low dose, filled these requirements in that it did not destroy and yet was sufficient to cause a change in the constitution of the tissues, as shown subsequently. The upper and lower limits of the dose which will cause this change to occur have yet to be determined.

One week following irradiation of the tumor *in vivo* with 100 r dose, the tumor was removed and inoculated into 46 mice of the following three strains: Bagg's albino, C_{57} of Little, and Strong's *CBA*. From these 46 inoculations, there were 23 takes or, in other words, these three strains which reacted first negatively to the non-irradiated tumor are susceptible to the irradiated tumor in that approximately 50 per cent of the animals inoculated react positively.

Simultaneous inoculations of the original dilute brown stock with irradiated and non-irradiated tumor fragments, showed 100 per cent takes in both cases.

Control experiments were carried on at the same time in order to check the possibility of a change in the tumor not associated with the radiation. A non-irradiated *dbrB* tumor was inoculated into all four strains with the following results. The three strains which were negative previously still reacted 100 per cent negatively and the original dilute brown strain 100 per cent positively; that is, the tumor had not changed spontaneously.

The radiated tumor now growing in one of the resistant strains, C_{57} *black*, was transplanted for three transplant generations into mice of this strain. The results as tabulated below indicate that there is a definite change which has been carried through four successive transplantations.

First inoculation		
6 positive	6 negative	
Second inoculation		
5 positive	9 negative	
Third inoculation		
5 positive	7 negative	
16 positive	22 negative	42% positive

Conclusion.—These results are based on only 46 animals and it is, therefore, unwise to draw any definite conclusions. However, there is no doubt but that some change has occurred to cause a specific tumor to become definitely non-specific. The completed work will be reported at some future time.

INVAGINATED APPENDICEAL STUMPS ROENTGENOLOGICALLY SIMULATING POLYPOID NEOPLASMS[1]

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THE inverted stump of the vermiform appendix may persist for some time as a bulbous mass projecting into the lumen of the cecum. In each of the following cases a small rounded or ovoid mass was found in the tip of the cecum at the site of the base of the appendix vermiformis. At operation the mass proved to be the persisting inverted appendiceal stump.

REPORT OF CASES

Case 1. A woman, aged 39 years, came to the Mayo Clinic in 1933, complaining of pain referred to the rectum. She had suffered from this for three years. In the six months just before she came to the Clinic, the pain had become worse and had been accompanied by a burning sensation in the lower part of the abdomen. On one occasion she had passed "pieces of meat and blood" from the rectum. The patient's physician had told her that this material was "a polyp." Appendectomy had been performed in 1915.

At physical examination tenderness to deep pressure in the lower right quadrant of the abdomen was noted. Proctoscopic examination revealed hemorrhoids but no other abnormal condition. At roentgenologic examination a polypoid lesion, 1.5 cm. in diameter, was found in the cecum.

At operation a small polypoid lesion about the size of a large coffee bean was removed from the head of the cecum. The pathologist's report read: "inflammatory submucous nodule, very likely the stump of the appendix."

Case 2. A man, aged 46 years, came to the Clinic in 1933 for general physical examination. He had no complaints other than obstinate constipation. Appendectomy had been performed in 1928. At roentgenologic examination of the colon, a small polypoid lesion of the cecum was found (Fig. 1).

At operation a small polypoid lesion was removed from the posterior wall of the cecum. Pathologic examination revealed that it was the inverted stump of the appendix.

Case 3. A woman, aged 60 years, came to the Clinic in 1938. She had had cramplike pains in the lower part of the abdomen for several years. Morphine sometimes had been needed for relief. Gastro-enterostomy had been done in 1928 and appendectomy and cholecystectomy had been performed in 1930. For some time before

[1] Accepted for publication in May, 1939.

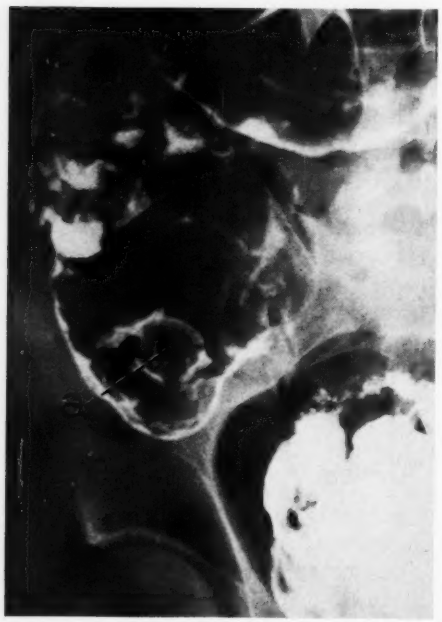

Fig. 1. Roentgenogram of colon made with double contrast method in Case 2; the polypoid lesion, in the cecum at *a*, proved at operation to be an invaginated appendiceal stump.

the patient was examined at the Clinic, the abdominal pains had become more severe and had been accompanied by abdominal distention, visible peristalsis, and occasionally by vomiting.

At physical examination a mass was felt in the lower right quadrant of the abdomen. This mass was thought to be feces in the cecum.

Roentgenographic examination of the abdomen revealed some dilated loops of small intestine. Roentgenologic examination of the colon revealed a small polypoid lesion of the cecum and the examiner suggested that it might be the inverted appendiceal stump (Fig. 2).

The pathologic examination of the small polypoid lesion that was removed surgically from the cecum revealed that it was the stump of the appendix. The surgeon thought that the inverted stump had been the cause of intermittent intussusception.

Case 4. A man, aged 44 years, came to the Clinic in 1938, after having suffered from indigestion for twenty years. Appendectomy and gastro-enterostomy had been performed in 1923 but had failed to relieve the symptoms.

At physical examination tenderness was noted in the right lower and left upper quadrants of the abdomen.

Roentgenologic examination of the colon gave evidence of diffuse ulcerative colitis confined to the cecum and ascending colon. In the cecum a polypoid lesion was found which was considered to be the invaginated appendiceal stump (Fig. 3).

Resection of the lower part of the ileum and the upper half of the colon was performed three months after an ileocolostomy had been established. Pathologic examination of the opened cecum disclosed the invaginated appendiceal stump and subsiding ulcerative colitis.

Other Cases. In each of four other cases a similar small polypoid lesion was found in the cecum at roentgenologic examination. In each case the lesion was considered to be the invaginated appendiceal stump. In each instance it was known that

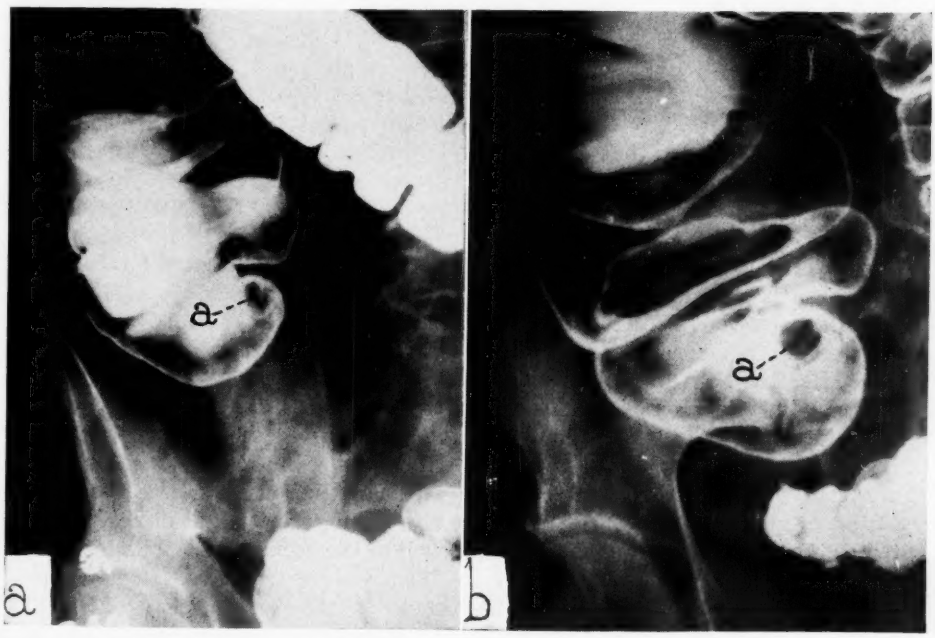

Fig. 2. Roentgenograms of the colon made with the double contrast method in Case 3. *A*, Roentgenogram made while the patient was supine. *B*, Roentgenogram made while the patient was prone. The well-circumscribed circular defect at *a* represents the invaginated appendiceal stump.

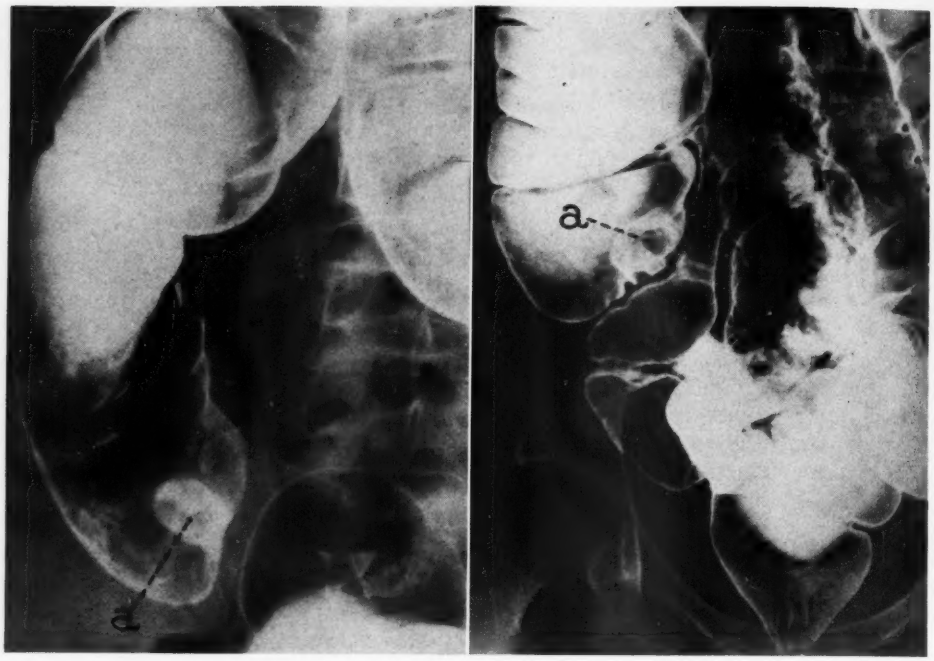

Fig. 3. Fig. 4.

Fig. 3. Roentgenogram made with the double contrast method in Case 4, showing the narrowed straight cecum and ascending segment of the colon. The polypoid defect at *a* proved at operation to be due to an invaginated appendiceal stump.

Fig. 4. The well-circumscribed shadow at *a* proved at operation to be a small lipomyxofibroma. Roentgenogram made with the double contrast method.

appendectomy had been performed. The patients were not referred for operation because it was not thought that the symptoms warranted such treatment.

ROENTGENOLOGIC DIAGNOSIS

The invaginated appendiceal stump may appear in the roentgenologic examination as a small, somewhat rounded or ovoid intraluminal filling defect in the tip of the cecum, at the usual site of the base of the vermiform appendix It may also be the cause of intussusception. At the roentgenoscopic examination of the colon, when the cecum is well distended with the contrast fluid, the filling defect is readily elicited as the cecum is compressed. After the contrast enema is evacuated the defect may still be seen, but perhaps not so distinctly. It is best demonstrated roentgenographically by using a modification of the double contrast method of Fischer and Weber. As soon as possible after the contrast enema is evacuated, the colon should be redistended with air under roentgenoscopic control. Stereoscopic roentgenograms are then made with the use of the Potter-Bucky diaphragm, while the patient is in such position that the cecal segment is projected to best advantage. The characteristic rounded or ovoid mass projecting into the cecal lumen may then be subjected to careful study.

The small mass may or may not be palpable, as the cecal segment which is the site of the filling defect is manipulated during the roentgenoscopic examination. If the defect is situated at or near the medial wall of the cecum, the possibility of an invaginated appendiceal stump should be given serious consideration. There are no well defined criteria by which the distinction between the filling defect caused by invaginated appendiceal stump and that

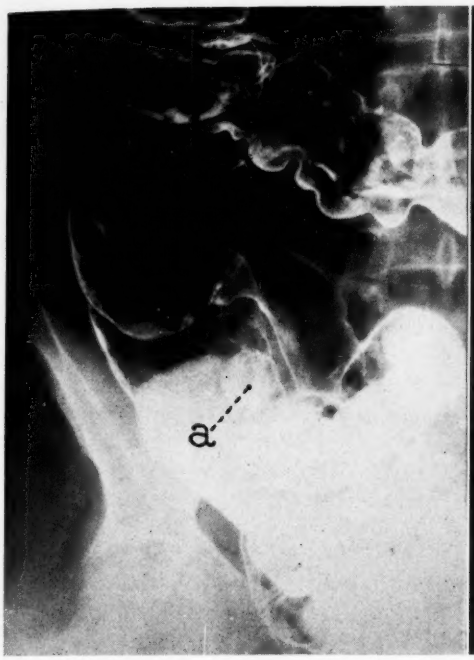

Fig. 5.

Fig. 6.

Fig. 5. The well-circumscribed polypoid lesion on the medial wall of the cecum at *a* proved, on microscopic examination after surgical removal, to be an adenoma. Roentgenogram made with double contrast method.
Fig. 6. Filling defect at tip of the cecum due to an extrinsic cause. At operation a carcinoma of the appendix was found. Roentgenogram made with the double contrast method

caused by a small polypoid neoplasm can be made. If the roentgenologist knows that the appendix has been removed, and if he can determine that the small rounded or ovoid mass is near the site of the base of the removed appendix, he has cause to suspect that he is dealing with nothing of more serious concern to his patient than an invaginated appendiceal stump. In this event the patient's disability and the nature of his complaint will be determining factors in the treatment. True neoplastic lesions may, however, have so nearly an identical roentgenologic appearance that distinction between the two types of lesions willalways be difficult and sometimes impossible. We have had occasion to observe benign polypoid lesions at the tip of the cecum (Figs. 4, 5, and 6), as well as some which on microscopic examination after removal proved to be malignant. It becomes apparent that only by a most intimate co-operation between the roentgenologist and the medical and surgical consultants will the proper direction of therapeutic effort be found.

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ROENTGEN THERAPY FOR PAINFUL CONDITIONS OF THE BONES AND JOINTS[1]

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From the Methodist Hospital

ALMOST since their discovery, roentgen rays have been used in the treatment of painful conditions of the nerves and of the bones and joints. That this therapeutic method has not achieved uniformly perfect results is attested not only by the published literature but also by the failure of its universal adoption. The earliest reports of the use of roentgen therapy in these conditions came from continental Europe. In 1897, Gocht (8) obtained analgesia in cases of trigeminal neuralgia, and Sokoloff (14) reported good results in the treatment of four cases of rheumatic diseases in children. Two years later, Grunmach (9) noted the production of definite analgesia in patients who suffered from neuralgia and articular rheumatism, and Stenbeck (15) treated 52 cases of articular rheumatism, with good results. Albers-Schönberg (1) stated, in 1900, that gout is favorably influenced by roentgen-ray therapy. The first American publication on the subject was that of Anders, Daland, and Pfahler (2) who, in 1906, used this method in the treatment of arthritis deformans. In the same year Wetterer (17) also reported the use of roentgen-ray therapy in arthritis deformans, and Comroe (5) published his results in the treatment of neuritis. The World War added impetus to this work, and traumatic injuries of peripheral nerves appeared to respond satisfactorily to roentgen therapy. In 1915, Cestan and Descomps (4) obtained improvement or cure in 50 per cent of disturbances accompanying traumatic peripheral nerve injuries, and, in 1916, Bonnus (3) published the report of his good results in the treatment of spasmodic and sensory disturbances produced by gunshot injuries of nerves. In 1916, Hesnard (10) explained this success by the demonstration, in animal experiments, of alterations produced by roentgen-ray treatment in and around injured nerves, facilitating the regeneration of nerve fibers. More numerous reports of the results obtained by roentgen-ray therapy of painful conditions of the bones and joints in larger series of cases have appeared in recent years. The publication of Kahlmeter (11) provided the chief impetus for our investigations.

There have been a number of explanations of the mechanism of action of roentgen therapy in painful conditions other than cancer. Desjardins (6) believed, in 1927, that roentgen rays exerted a specific action on nerve cells with the production of diminished irritability. He now believes, on the basis of his own experience and review of recent experimental studies (7), that the effects obtained in the treatment of inflammatory processes are attributable directly or indirectly to the destruction of leukocytes. In the treatment of joints, for instance, the leukocytolysis results in lessened peri-articular and reduced perivascular and perineural infiltration. Chemical changes with disturbance of the electrolytic balance between the cells and humoral systems, changes in colloids and crystalloids, as well as activation of antigens and cell immunity, have been considered to explain the mechanism of action of roentgen therapy in inflammatory conditions. Mischtschenko and his coworkers (12) attributed the analgesic properties to the action of split proteins and lipoids on the nerve endings.

Our interest in the therapeutic value of roentgen rays in painful conditions of the bones and joints was stimulated by one of us (E. B. M.) in the treatment of acute osteoporosis. Turner, in his work on osteoporosis, had concluded that this bone con-

[1] Accepted for publication in March, 1939.

dition was brought about through the liberation in the bone of a substance (acetylcholine) which acted either as a solvent for the mineral salts or as a vasodilator, producing an increase of blood flow and the absorption of bone calcium. It was, further, his belief that this substance was liberated through the sensory (pain) stimuli arising from extraneous inflammatory reaction. His therapeutic attack was to block these afferent sensory nerves. With knowledge of the analgesic effect of the roentgen ray, we considered it feasible to eliminate the pain stimuli in osteoporosis by roentgen therapy rather than by local blocking of nerves. The results were most startling and have been reported (13). In seven of eight cases, pain was relieved and function returned. We believe that this is the first definite plan of treatment for osteoporosis.

In one case with considerable pain and loss of function following a compound fracture of the os calcis, roentgen therapy was given to prepare a large denuded area for skin graft. After the second roentgen-ray treatment, all pain had disappeared and almost complete restoration of function occurred. This observation suggested the treatment of cases of infection associated with painful stiff joints. Here, again, excellent results were obtained. As a result of these findings we feel that in many cases in which loss of function has followed infection and has been attributed to adhesions in and about the tendon sheaths and joint capsules, the loss of function is due to muscle spasm. Through roentgen therapy the pain is relieved, the muscle spasm disappears, and function returns.

We wish now to report the treatment of a larger group of patients who had pain about the bones and joints resulting from trauma, arthritis, and infections. Periods of from four to eighteen months have elapsed since the 90 cases in this group were treated. All cases reported replied to follow-up questionnaires, but 15 cases in which adequate follow-up data could not be obtained, as well as 20 cases treated recently, have not been included.

We will consider first the largest group, that in which the patient's disability was the result of trauma (Table I). In this group are 52 cases—27 of post-fracture pain—many of them associated with osteoporosis; 14 had suffered traumatism but no fracture could be demonstrated; five suffered from painful joints following surgery; four complained of painful joints probably due to muscular strain but without other definite trauma, and two had painful extremities with limitation of joint motion, following infected burns. Of this entire group the best results were obtained in the cases with post-operative pain, 80 per cent of whom noted improvement which ranged from slight in one case, to great improvement in one, and complete disappearance of pain in two.

TABLE I.—TRAUMATIC CASES

	Degree of Improvement							
	Pain				Stiffness			
	Complete	Great	Slight	None	Complete	Great	Slight	None
Post-fracture	5	8	2	12	4	8	2	13
Post-trauma, no fracture	3	3	3	5	0	5	3	6
Burns	0	1	0	1	0	1	0	1
Post-operative	2	1	1	1	2	1	1	1
Painful joint, no definite trauma	1	0	0	3	1	0	0	3

The poorest results were obtained in the group in which no specific injury had occurred other than possible muscular strain. In only one of these patients did the pain disappear, while three noted no improvement. The largest group, those patients who had painful joints following fracture, obtained improvement in 56 per cent, while 64 per cent of the group who had had traumatic injuries of the joints but no fracture were improved, but the improvement was not so great in degree among these patients, being only slight in 43 per cent. The amelioration of pain and diminution in stiffness occurred most frequently during treatment but in a number of instances was not appreciable until a number of weeks afterward. Only 7 per cent had a temporary exacerbation of symptoms and 18 per cent

had transient discoloration or tanning of the skin over the treated areas. Several of the patients (7 per cent) commented on the fact that the general appearance and tone of the soft tissues about the treated joints were improved. In the traumatic group, with or without fracture, the improvement was in most instances permanent, although a few patients had recurrence of symptoms after three or four weeks. In several instances two or even three courses of treatment were required to obtain the optimum benefit.

TABLE II.—ARTHRITIS

Type of Case	Degree of Improvement: Pain				Stiffness			
	Complete	Great	Slight	None	Complete	Great	Slight	None
Hypertrophic	0	7	6	2	0	7	5	3
Atrophic	1	5	1	1	1	4	2	1
Gonorrheal	0	1	0	0	0	0	1	0
Fibrositis	2	1	0	0	2	1	0	0
Vertebral osteoporosis	0	0	1	2	0	0	1	2
Sciatic neuritis	0	0	0	1	0	0	0	1
Bursitis	2	1	1	0	2	1	1	0

The relief by roentgen therapy of the pain and stiffness which followed fracture was striking in the case of J. R. E., a white male 21 years of age, who had suffered compound comminuted fractures of the bones of the forearm in an automobile accident. The arm had been badly mangled and at the time of treatment, six weeks after the accident, was very painful; motion was limited at least 90 per cent, with every indication that the disability would be permanent. In reply to a questionnaire sent two months after the last treatment, he stated that he had regained full control of the hand and wrist and that pain had been relieved. The response began after the second treatment. No tanning occurred but the skin regained the natural color and consistency, whereas before treatment it had been red, with a brawny induration.

Mrs. L. D., a 66-year-old white woman, had suffered severe lacerations of the hand and forearm but no fracture of any of the bones when her hand and forearm were caught in an electric wringer. Two months afterward there was severe pain and a considerable degree of stiffness of these structures. She was treated with roentgen-ray therapy but during the period of treatment little significant response was noted. Six months later she stated that the pain and stiffness had been relieved shortly after treatment and that the improvement had been permanent. The appearance of the skin was improved and no tenderness or constitutional reaction had occurred at any time.

The second largest group was that of 35 patients suffering from arthritis (Table II). In 15 instances the arthritis was of the hypertrophic and in eight of the atrophic variety. Four cases of sub-deltoid bursitis, three of fibrositis, and one of gonorrheal arthritis were treated. Most of the patients in the fibrositis and bursitis groups obtained complete relief of pain and a great degree of improvement in most of the affected joints. No patient in these groups failed to be benefited by treatment and the single case of gonorrheal arthritis was greatly improved. Approximately 87 per cent of the patients in the atrophic and hypertrophic arthritis groups obtained relief; in the atrophic group the improvement was great in all but one case, and this patient was slightly improved. Moderate tanning of the skin followed treatment in 20 per cent of the cases. Systemic reaction to roentgen therapy, occasionally manifested by nausea and vomiting, was not infrequently encountered in the arthritic group, because relatively large doses had to be given due to the treatment of several joints. Although in many instances the improvement occurred during the period of treatment, there was generally a longer interval of time between treatment and relief in the arthritic than in the traumatic cases which responded. This period varied from one to six weeks. In general more than one course of treatment is recommended in arthritis because of the chronic and recurrent nature of the disease. While

a majority of the patients obtained relief which persisted for several months, we anticipate that many will suffer a recurrence of symptoms and will require several series of treatments. No extensive hematologic studies have been made in any of our cases and we are aware that the anemia so frequently found in arthritis may be accentuated by roentgen-ray therapy. To date, however, no significant clinical evidence of such an untoward effect has been demonstrated in the patients we have treated. An occasional case has been encountered in which the arthritic symptoms were aggravated for a variable period of time after treatment.

The results of treatment of hypertrophic arthritis are illustrated in the case of C. J. B., a white male, 61 years of age, who had suffered with hypertrophic arthritis of the left hip for years. In reply to a questionnaire sent two months after treatment was completed, he stated that he had experienced a marked degree of pain relief and was better able to use his hip, the improvement having appeared immediately after completion of treatment. No untoward symptoms occurred, other than slight tanning of the skin over the treated areas.

Mrs. C. E., white, aged 44 years, had had atrophic arthritis of both knees for ten months and at the time she was first seen she was able to get out of a wheel chair only with great difficulty. Improvement of motion was so marked that she was able to walk with the aid of crutches by the time treatment was completed. When last seen, six months after treatment, she still required a cane. Relief of pain was a striking manifestation in her response.

Too small a group of infections involving bone has been treated to enable us to evaluate satisfactorily the effectiveness of roentgen-ray therapy in such conditions (Table III). In one case of osteomyelitis, with open drainage, there was a prompt diminution of pain. Drainage became much less profuse and healing of the wound appeared to be accelerated. In two cases of osteomyelitis without drainage, cure appears to have resulted. In one of these cases, the action of roentgen-ray therapy was prompt, with a considerable degree of immediate relief, whereas in the other, a longer interval occurred between treatment and the amelioration of symptoms. The long recognized effectiveness of roentgen-ray therapy in the treatment of the cellulitis that sometimes follows dental extraction was again demonstrated by the prompt relief of discomfort in one such case.

TABLE III.—INFECTIONS

	Degree of Improvement							
	Pain				Stiffness			
	Complete	Great	Slight	None	Complete	Great	Slight	None
Osteomyelitis (with drainage)	0	1	0	0	0	1	0	0
Osteomyelitis (without drainage)	1	1	0	0	1	1	0	0
Dental extraction	0	1	0	0	0	1	0	0

Three elderly patients who had vertebral osteoporosis, associated with pain and consequent disability, were treated with unsatisfactory results. Only one of these three cases secured any relief, and this was only moderate in degree. For eight years she had been unable to turn over in bed and found it necessary to sleep on her back, whereas after treatment she found that she could assume any position in bed without discomfort. One patient believed that her back was somewhat more stiff after treatment than it had been before. One case of sciatic neuritis was treated with little relief of pain or stiffness.

The technic of treatment is simple, and a relatively slight investment of the patient's time and money is required. In this series all cases have been treated with roentgen rays generated at 200 kv. and 25 ma. of current. A filtration of 0.5 mm. Cu and 1 mm. Al has been used, with a target–skin distance of 50 cm., and fields varying in size according to the part treated. Four applications of 100 r have been given, and there should be an interval of two or three days between treatments. Thus a small total dose of roentgen rays has been applied in each case.

The results obtained by treatment with roentgen rays, in this group of painful conditions involving the bones and joints, are, in general, most encouraging. While the method cannot be regarded as a cure-all, and many patients experience no relief, we believe that a greater percentage of improvement was obtained than could have been effected by any other method of treatment. In a number of instances almost miraculous results occurred: patients walked who had for some time been unable to, or regained the use of hands or arms that were thought to have been hopelessly crippled.

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RADIUM THERAPY IN POLYPOID ETHMOIDITIS[1]

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THE ethmoid labyrinth, occupying one-half the space between the floor of the nose and cribriform plate, is composed of two capsules, one on either side of the lamina perpendicularis. Each ethmoid capsule contains two groups of cells, the anterior and the posterior. The number of cells in each group may vary from three to thirteen. The anterior cells drain underneath the middle turbinate into the middle nasal passage, and the superior cells drain into the superior nasal passage. Unlike the other nasal sinuses the ethmoid is not enclosed in bony walls but in the respiratory portion of the nose, and has the function of warming and moistening the inspired air.

By introducing a long speculum between the middle turbinate and the lateral wall of the nose the ethmoid bulla and surrounding tissue may come into view, thereby exposing oftentimes pearl-like polyp buds. Associated suppurative infection of the sinuses may or may not be present.

Woakes, of London, in 1885, was the first to call our attention, clinically, to the association of nasal polyps and ethmoid disease. Hajek, of Berlin, in 1896, was the first to make a microscopic study of nasal polypoid tissue. According to Eggston, of New York, hypertrophic sinusitis is the most common variety and is characterized by an increase in the thickness of the epithelial layers with some infiltration of leukocytes and lymphocytes. The stroma is edematous and infiltrated with lymphocytes, plasma cells, and eosinophils. The walls of the veins and lymph vessels are infiltrated, and there are varying degrees of periphlebitis and perilymphangitis. In the later stages there is marked edema of the stroma, with filling of the interstitial spaces with fluid and separation of fibrous tissue fibrils. The fibrous tissue increases, the elastic tissue diminishes, and the turgescence of tissue continues to form polypoid masses. The surface epithelium becomes thin, due to pressure, and the mucous glands show cystic degeneration. The periosteum becomes broad and edematous, the fibers are widely separated by fluid, and ultimately the bony structure shows signs of absorption and osteoporosis. It is little wonder, therefore, that altered function of the nasal mucous membrane results from the extreme variations of the vascular supply. The nose is a barometer which reacts to numerous intrinsic and extrinsic stimuli.

The polyps may appear as myxomatous, adenomatous, and angio-fibro-myxomatous varieties. The symptoms of polypoid ethmoiditis depend upon the extent and severity of the disease. Nasal obstruction, mucoid or mucopurulent discharge, headaches, loss of the sense of smell, bronchitis, and asthma are the chief symptoms.

Conservative measures have largely replaced radical operations in chronic sinusitis. A Caldwell-Luc operation is usually necessary, however, if the maxillary antrum is filled with polyps; otherwise drainage through an antro-nasal window will give astonishing results. A submucous resection for a deviated septum is a conservative measure, allowing for better aeration and drainage of the sinuses.

If the polyps in the ethmoid area are few and of large size, a more conservative removal is suggested. A more extensive operation should precede the application of radium if the entire ethmoid capsule shows polypoid degeneration. It is difficult to remove all the ethmoid cells, hence the tendency to recurrences. The late Dr. Sluder has stated that regardless of the surgery—conservative or radical—the

[1] Read before the Fifth International Congress of Radiology, at Chicago Sept. 13–17, 1937.

end-result is that the patient still has polyps.

Radium and other physical agents have been used postoperatively in polypoid sinusitis with considerable benefit. The action of radium upon this pseudo-tumor tissue is to produce a fibrosis in the submucosa. It is noted that after radium treatments fewer polyps recur, and that they are decidedly more fibrous in character than the usual myxomatous variety. The interval between recurrences is lengthened, and the nasal discharge diminished. The radiation treatment consists in the application to each ethmoid area of a 50-milligram radium capsule screened with 0.5 mm. platinum, giving 150 to 200 milligram-hours per treatment. The applications are made at intervals of ten days to two weeks for an average of four treatments. A double string of silk or dental floss is attached to a small ring in one end of the radium capsule. Vaseline packing is used to maintain the position, and is applied between the tube and septum to prevent over-action of the radium on the septal mucosa. The loose end of the string is strapped securely to the patient's cheek and around the ear, as there is a possibility of the tube being dislodged to the nasopharynx and swallowed.

In a small group of cases, usually in young individuals, in which there are large vascular polyps, gold radon implants of 1.0 millicurie each may be inserted into the tumor tissue. Hemorrhage is thus controlled and operation is performed four to six weeks later. This type of treatment also applies to another pathologic process, the fibromas of the nasopharynx, many of which will disappear after radium treatment or reduce in size and be made avascular and rendered safely operable.

SUMMARY

My experience in the treatment of polypoid ethmoiditis with radium reveals:

1. The mucoid and mucopurulent secretions have been lessened.

2. Headaches have been relieved and in a few cases the sense of smell has returned.

3. Asthma, when present, and due to ethmoiditis, has been controlled in the majority of cases.

4. Small polyps have been made to disappear and the interval between recurrences has been lengthened.

5. The complications, such as bone necrosis and perforated septum, are very rare if radium is carefully applied.

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DISTRIBUTION OF RADIATION IN PERVAGINAL ROENTGEN THERAPY[1]

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THERE is every reason to warrant the opinion that the general practice of combining roentgen and radium therapy produces the largest number of five-year apparent cures in cancer of the cervix uteri of any method of treatment yet devised. As radiologists, we have for some time enjoyed a free hand in the management of this form of cancer, and although definite progress has been made, we must, nevertheless, face the disquieting fact that the present results obtained in the larger cancer clinics, using different technics, all vary only slightly from 25 per cent of questionable cures, when stages are grouped together. This situation is not a satisfying one, and indicates that more radical changes in our methods must ensue, if we are to cope adequately with this disease.

The present outlook in this form of cancer may be summarized as follows: If the disease is confined to the cervix and not made to metastasize by injudicious handling, the ultimate results are good in a considerable percentage of cases. If there is slight spread to the parametrium and adjacent vaginal wall, the ultimate results may be good still, provided extensions are within the field of local irradiation. If the growth has extended to lymph nodes or beyond the effective field of local irradiation, the ultimate results are poor. The chief need, therefore, is for a method of delivering a greater amount of irradiation into the areas of the pelvis immediately beyond the zone of present effective local treatment.

Radium applied to the cervix will control the disease in the primary lesion, in most instances, but, within reasonable limits of tissue damage, it will not deliver a lethal dose to tumor tissue located at a distance little greater than 3 cm. from the cervical canal. Therefore, some other source of radiation must be relied upon to treat adequately parametrial and outlying tumor-bearing regions. External radiation has become more efficient by the use of six fields and long target–skin distances, also by the more recently available supervoltage machines with greater filtration; but it is unlikely that patients would tolerate the amount of external irradiation required to deliver the same dose to the parametrial regions as is obtained throughout most of the primary lesion from radium applied to the cervix. It is true that when both agents are utilized one supplements the other so that the total volume of tissue receiving a lethal dose is increased, but still shows some inadequacy. It is evident that the only cases in which we can hope for a cure by our present methods are the early localized lesions and the more extensive but radiosensitive cancers.

In order to obtain a better depth dose and an improved distribution of radiation in the pelvis, Merritt (3) has resumed a method of intravaginal therapy which he devised in 1921, but discontinued until the

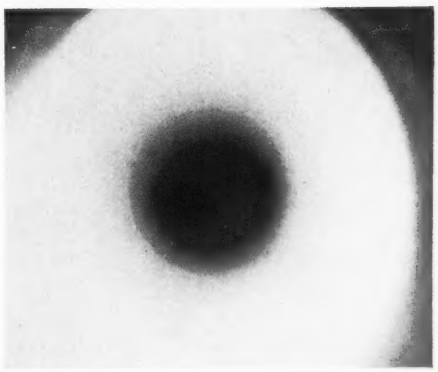


Fig. 1. Radiograph of pervaginal beam at surface of cervix uteri. Diameter of main beam 5.5 cm.

[1] Presented before the Mid-winter Session of the Canadian Association of Radiologists, at Kingston, Ontario, Jan. 6, 1939.

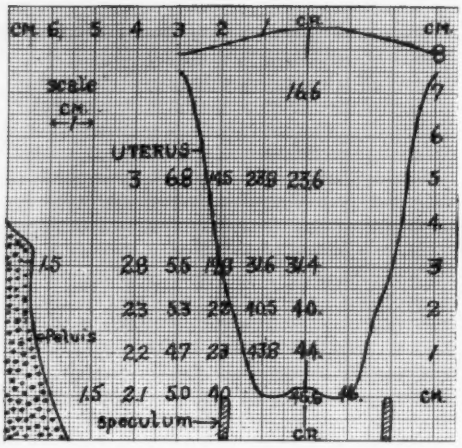


Fig. 2.

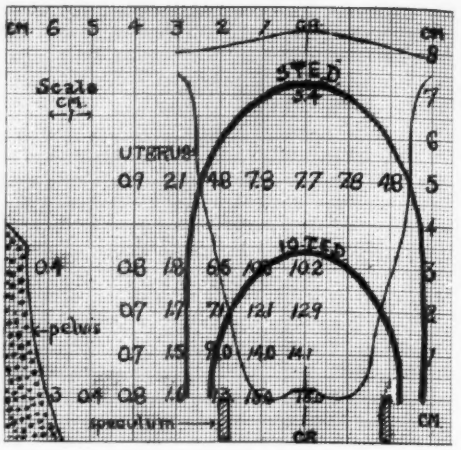


Fig. 3.

Fig. 2. Distribution of pervaginal roentgen radiation. Ionization measurements in r/min.
Fig. 3. Distribution of pervaginal roentgen radiation. Tissue dose in T.E.D.'s in series of 7,000 r (air).

advent of shock-proof equipment. The procedure is now on trial in several laboratories throughout this continent. The development of the method is based upon the fact that the chief limiting factor to the administration of a cancericidal dose to any deep-seated tumor is the tolerance of the normal intervening structures, especially the skin. If the deep lesion can be exposed directly to a beam of x-rays without the beam having to traverse normal tissue, a cancericidal dose can be safely administered. Carcinoma of the uterine cervix lends itself to this plan of attack because the cervix can be exposed through the vagina and treated as a superficial lesion. The equipment used by the author consists of a bakelite speculum of a modified Ferguson type with an obturator which is inserted into the vagina, displacing the vaginal walls, bladder, and rectum. The obturator is then removed, the speculum fitted over the cervix, and connected at its outer end with a short master cone attached to the shock-proof tube-head. Four sizes of vaginal specula, 7.2 cm. long and varying in diameter from 3.5 to 4 cm., are utilized, so that maximum separation of the vaginal walls is possible in all cases. The master cone permits the passage of a beam measuring 3.5 cm. in diameter, which diverges to a field 5.5 cm. in diameter at the cervix and the inner end of the speculum. The distance from the focal spot of the tube to the cervix is 42.5 cm. Although the vaginal walls are not pushed completely out of the beam by the bakelite speculum, undue reactions in these structures are not observed clinically. The patient is postured in the lithotomy position for insertion of the speculum, and the couch then moved so that the flanged outer end of the inserted speculum fits over the end of the master cone and remains in contact with it. Care is required in properly aligning the cone and speculum by sighting in vertical and horizontal planes just before contact.

Daily doses of 450 r are administered until a total of from 6,000 to 7,000 r is delivered to the cervix, requiring about two weeks. The usual external roentgen series is given immediately following the local treatment. When supplementary radium treatment is deemed advisable, it is administered as soon as subsidence of the radiation reaction in the vaginal canal permits.

The purpose of this presentation is to indicate the computation of the tissue dosage of radiation in and around the cervix uteri,

when it is treated by the pervaginal roentgen method outlined above. No record of any previous calculation of this energy distribution appears in the literature to date.

Using the rice phantom and the Victoreen condenser type of r meter, multiple measurements were made throughout an area corresponding to the uterus, parametrium, bladder, and rectum. From these data, isodose curves were constructed, employing the threshold erythema dose of 525 r as a unit, in order to permit comparison of the dosage distribution with existing tables of radium dosage. The size of the uterus on which the isodose curves were plotted measured 8.0 × 5.0 × 3.5 mm., being the usual average given for multiparous uteri. The uterus has been shown lying in a plane almost parallel to the patient's length, because most uteri will assume this axis with the patient in the supine posture. The isodose curves were constructed in two planes, median coronal and median sagittal, the former to indicate the distribution of radiation lateral to the uterus, and the latter plane to indicate the dose received by the bladder and rectum. Figure 1 shows the roentgenographic image of the pervaginal beam at the level of the cervix, the main beam having a diameter of 5.5 cm. Figure 2 shows the ionization chamber measurements in r/min. throughout the pelvic area. Figure 3 shows the distribution of energy in terms of threshold erythema doses (525 r, measured in air), in a pervaginal series of treatments, in which 7,000 r, measured in air, are administered. Note that a cancericidal dose of about 10 threshold erythemas is administered to an area slightly over 2 mm. from the cervical canal, more than 3 cm. in depth, and that no portion receives a dose in excess of 15 threshold erythema doses. Figure 4 shows the distribution of pervaginal radiation in the median sagittal section. Note that all portions of the rectum and bladder receive less than five threshold erythemas.

In comparing the delivered dosage of radiation by pervaginal roentgen therapy and the various methods of radium application available to meet the requirements and limitations of the different anatomicopathologic conditions encountered, the criteria by which the efficiency of any method may be judged are based upon the expressions of amount of radiation reaching any given point. In each instance several factors are to be considered. The dose delivered to the primary lesion must be sufficient to control the disease in this region, but amounts of radiation that will cause a marked degree of necrosis and sloughing should be avoided. Data presented by Arneson and Stewart (2) indicate that in most instances a minimum dose of from six to eight threshold erythemas is required to destroy completely the primary disease in the cervix. Sloughing and necrosis will probably occur in tissues receiving greater than 15 T.E.D.'s. On the other hand, the most radiosensitive tumor in the cervix will probably not be destroyed unless as much as five T.E.D.'s are delivered to it. The dose delivered to the parametria is of extreme importance, because inadequacy in this regard is probably the greatest deficiency of present day methods of management. The most suitable method would be the one that delivered a lethal dose to the greatest volume of tumor tissue without over-irradiating any particular region. Table I indicates the distribution of cancericidal doses by pervaginal x-radiation in comparison with the various common methods of local radium treatment as compiled by Arneson (1). The radium filter in every instance was equivalent to 2 mm. brass. The table shows that the greatest increase in the distance lateral to the cervical canal to which a cancericidal dose is delivered is obtained in the method of administering radium by the colpostat, in cases in which anatomicopathologic conditions permit of this technic. Pervaginal roentgen therapy has a slightly wider distribution of efficient cancericidal radiation than methods of radium application, and has the further advantage that overdosage of the canal region is avoided.

Not only must the distribution throughout the tumor-bearing area be considered,

but attention must be given also to the dose delivered to the bladder and rectum. In many cases these regions are not infiltrated by the disease and must be protected from excessive dosage. Table I shows the maximum amount of radiation that is delivered to these areas by the various methods, but it should be noted that only the portion of these organs adjacent to the uterus receives these doses. In the pervaginal roentgen therapy no area more than 3 cm. from the uterine canal receives more than 2 T.E.D.'s, so that the bladder and rectum would appear to enjoy relative protection by this method. However, it should be recognized that the size and po-

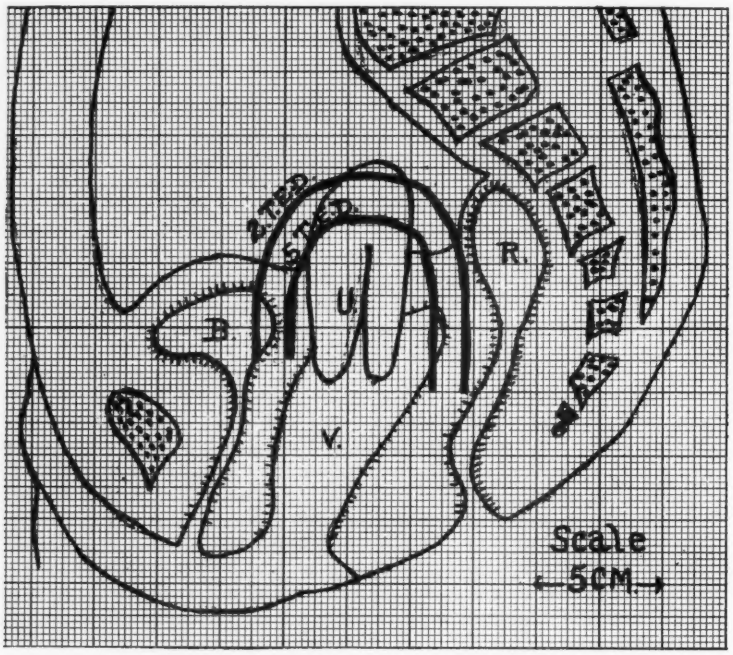


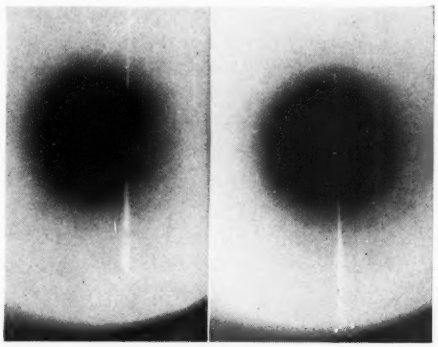
Fig. 4. Distribution of pervaginal roentgen radiation. Median sagittal section.

TABLE I.—COMPARISON OF DISTRIBUTION OF RADIATION BY DIFFERENT METHODS OF LOCAL TREATMENT OF CERVIX UTERI

Methods of Application of Radium	T.E.D. Delivered to 2 cm. Cylinder around Uterine Canal	Cm. Lateral to Cervical Canal that 15 T.E.D. are Delivered	Cm. Lateral to Middle of Cervical Canal that 7 T.E.D. are Delivered	Maximum No. T.E.D. Delivered to Bladder and Rectum
Tandem for 3,000 mg.-hr.	25	1.0	2	5
Tandem plus Bomb 3,000 mg.-hr. 1,500	25	1.3	2.1	6
Tandem plus Plaque 3,000 mg.-hr. 1,500	25	1.3	2.1	7
Tandem for 5,000 mg.-hr.	40	1.5	2.5	8
Tandem 3,000 hr. plus Colpostat 2,000 mg.-hr.	25	3	3.3	7
Pervaginal Roentgen Therapy 7,000 r (air)	15	1.8	1.7	4

sition of the uterus and the extent of the lesion are too variable to fix exact radiating points for plotting curves. Furthermore, accurate localization of the beam seems difficult to standardize. It is interesting to note that in the calibration procedures which formed the basis of this presentation differences of as much as 50 per cent were encountered between the measurements of each side of the assumed margin of the primary beam. These were found to be due to slight misalignment of the cone and speculum, not readily apparent by inspection, and demonstrated the apparent disadvantage of external methods of alignment. While periscopic control would appear advantageous, the great variability in ionization measurements at the same distance from the different surfaces of the speculum, when in good visual alignment, raises doubt as to the absolute efficiency of even the periscopic method of centering. Misalignment would, of course, mean wider irradiation of the parametria on one side, and, if controllable, would seem to offer definite advantages. Figure 5 demonstrates roentgenographically the effect of misalignment of the master cone and speculum. In Figure 5, *A* shows the deviation of the beam by angulating the cone 2.5 degrees after a metallic pointer was placed in the path of the central ray with the cone and speculum in good alignment. About 1.5 cm. lateral shift of the beam is noted under these conditions. The slight shift of the beam (Fig. 5-*B*) is the result of the least misalignment definitely noticeable by external visual method of alignment, and indicates that this method of centering the beam is apparently satisfactory for practical purposes.

Other factors to be considered in comparing the roentgen and radium methods of local treatment are the time factor and quality of the irradiation. In radiation therapy the time factor with its resultant tissue recuperation factor has not been fully elucidated, but comparison of the technics employed in various centers, using a wide variety of periods of irradiation, shows essentially the same results. The daily continuous or interrupted series of pervaginal roentgen treatments would seem to fulfill adequately all requirements in the light of our present knowledge of this factor.



A *B*

Fig. 5. Effect of misalignment of cone and speculum. *A* shows wide shift of beam with 2.5-degree angulation; *B* shows the very slight shift from least definite external visual misalignment.

In the matter of wave length of the radiation, the roentgen method may possibly be at some disadvantage. In several laboratories a beam generated at 220 kv.p. is utilized, with filtration equivalent to 2 mm. of copper, in order to improve the quality of the radiation. However, as tissue reactions appear more dependent upon the distance from the source of radiation than upon quality of the beam and as a great depth dose is not required, it would seem that until such time as more definite evidence is produced to indicate the advantages in biologic effect on the cancer cell and decreased local tissue reaction by the use of short wave lengths, x-rays generated at 200 kv.p. and 0.5 mm. Cu filtration would seem to be satisfactory and more economical.

SUMMARY AND CONCLUSIONS

The distribution of radiation throughout the average female pelvis has been studied for the pervaginal method of roentgen therapy. A comparison is made of the relative effectiveness of this method and various common methods of radium

application in terms of T.E.D. supposed necessary for a lethal effect on cancer of the cervix uteri. Appraisal of the computed dosage delivered in the pelvis by pervaginal roentgen therapy indicates its apparent equal efficiency to radium, as local treatment of Stages I and II of carcinoma of the cervix uteri. Apparent advantages offered by the roentgen method are the avoidance of excessive radiation to the immediate canal area, the bladder, and the rectum. Assuming accurate centering of the beam on the cervix, pervaginal roentgen therapy would appear to be inferior to the combined use of radium in the colpostat in the cervical canal as a method of treating the parametrium.

COMMENT

The problem of adequately irradiating the parametrium appears to be still unsolved. Because the colpostat radium applicators lie only 0.75 cm. from the vaginal mucosa, this tissue receives a tolerance dose of 15 T.E.D.'s in 1,200 mg.-hr., while at 3 cm. depth, only 1.6 T.E.D.'s are delivered. For improved depth dosage percentage, it would seem more logical to irradiate the parametrium from a distant source of energy. The vaginal bomb is better designed for delivering depth dose, but its field is the same as that of radium in the cervical canal in which case the dosage is limited by the tolerance of the adjacent tissues. Progress would appear to lie in the development of a method of exposing the parametrium to a restricted beam of radiation from a large quantity of radium in the vaginal vault or by pervaginal roentgen therapy directed into the vaginal fornices with adequately controlled distribution.

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EXPERIENCES WITH A COMPRESSION DEVICE IN EXAMINATIONS OF THE ALIMENTARY TRACT[1]

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COMPRESSION of the stomach or intestine by the fluoroscopist with the gloved hand or a wooden device was a natural development of the roentgen method of examination of the gastro-intestinal tract. By this maneuver flexibility of the wall of the stomach, crater shadows not brought into profile, and mucosal folds could be demonstrated. After Forssell (1) described the formation of gastric mucosal folds by the independent movement of the muscularis mucosæ, Åkerlund (2), Berg (3), and others emphasized the clinical importance of mucosal relief studies with relatively small quantities of barium suspension. They devised apparatus for making a permanent record on films during fluoroscopy of portions of the gastro-intestinal tract while pressure is being applied.

Compression films provide greater detail than the fluoroscopic screen and can be studied at leisure. Although they do not displace careful fluoroscopic observation, undoubtedly more information can be obtained with than without them.

It is obvious that pressure cannot be applied to certain regions of the alimentary tract, for example, the esophagus and the fundus of the stomach. The apparatus is just as important in those cases, however, as it permits the making of roentgenograms

[1] Presented before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

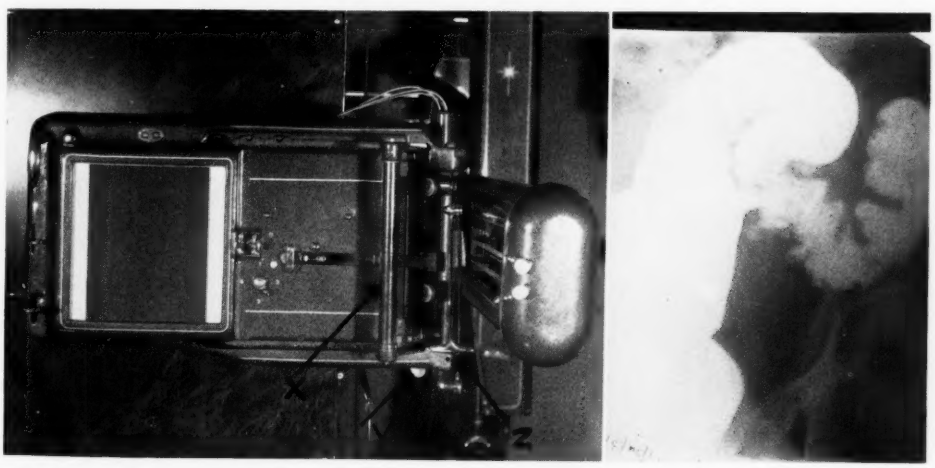

Fig. 1-*A*. The apparatus used by the writers consists of a combined fluoroscopic screen, cassette tunnel, and mechanism for switching instantly from a fluoroscopic to a roentgenographic setting. Handle, *X*, moves the cassette into and out of the path of the x-ray beam and at the same time activates a relay which changes the milliamperage and switches the timer into the circuit. The exposure is made by the foot switch. Handle, *Y*, brings the compression cone into place. Handle, *Z*, raises and lowers the whole carriage to bring the central ray through the center of the compression cone. A Lysholm grid can be added, if desired. The whole apparatus is attached to a motor-driven tilt table. In *A*, the shutters are wide open for exposure of the whole 8 × 10 film. The field is mapped out in black on the 10 × 10 fluoroscopic screen. It is frequently used to take an oblique projection of the sigmoid colon during a barium enema. The sigmoid is brought into profile as illustrated.

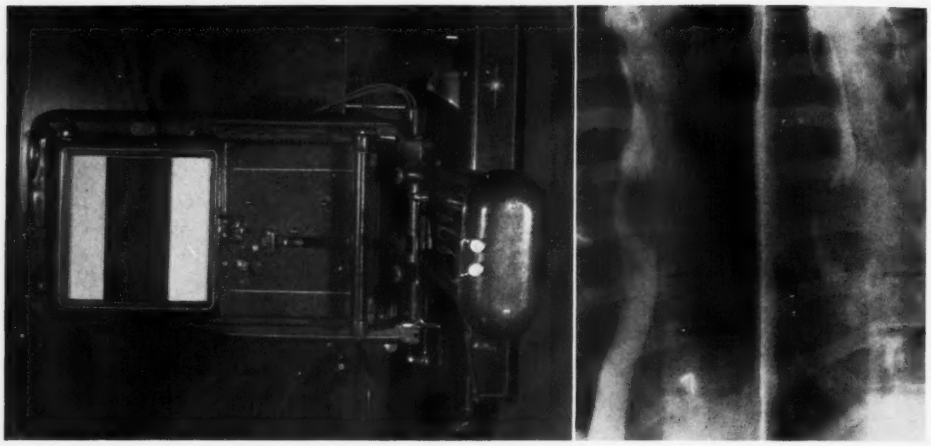

Fig. 1-*B*. The shutters are set for two vertical exposures, 4 × 10 inches. Mediastinal gland pressure on the esophagus.

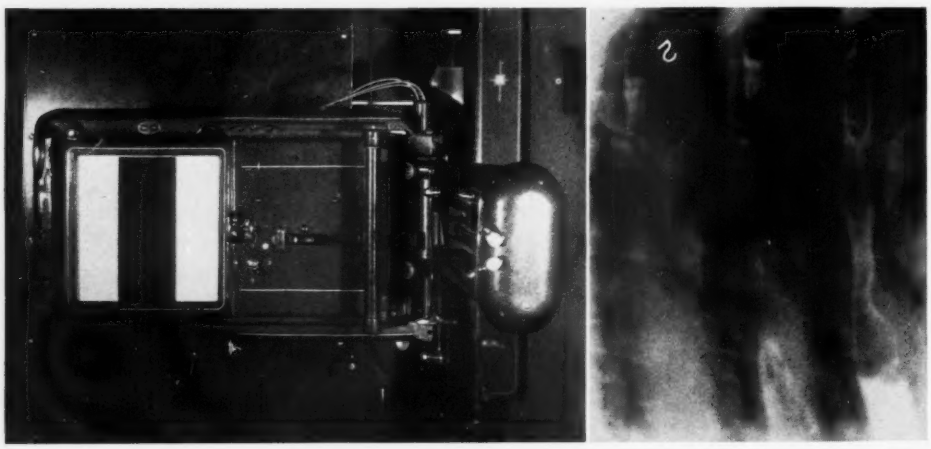

Fig. 1-*C*. The shutters are set for three vertical exposures, about 2.5 × 10 inches. Carcinoma of the breast secondarily invading the esophagus.

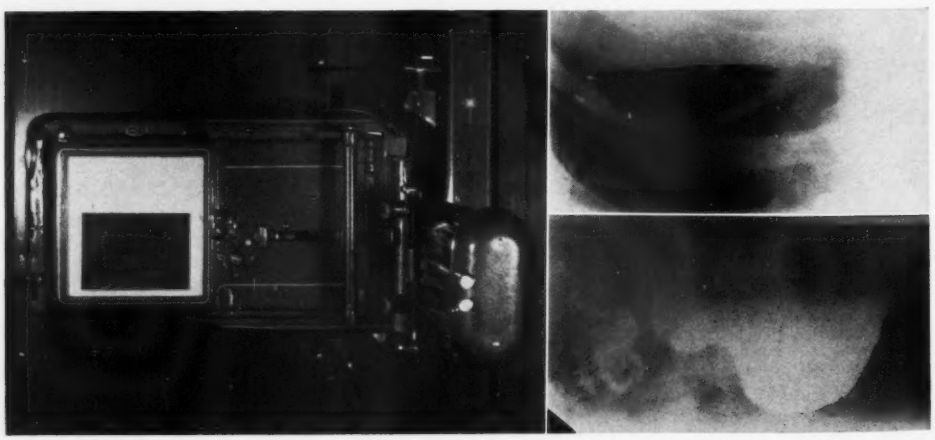

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Fig. 1-*D*. The shutters are set for splitting the 8 × 10 film horizontally into two 5 × 8 inch exposures. Handle, *Z*, is raised. One image is upside down since the cassette is automatically inverted between the two exposures. The film shows the gas bubble at the top of a long stomach and also a barium residue in the antrum; the stomach was too long to be included on an 8 × 10 inch film.

instantly when just the right amount of barium suspension is present to show the mucosal contours and when the patient is in the optimum position.

The earlier workers with this type of equipment were interested primarily in compression studies of the stomach and duodenum. Less has been written about its application to diagnostic problems in other sections of the alimentary tract. We have the impression that in our department almost as many compression films are made of the small intestine as of the duodenum. This communication will deal with some experiences in the use of rapid shift-over equipment, either with or

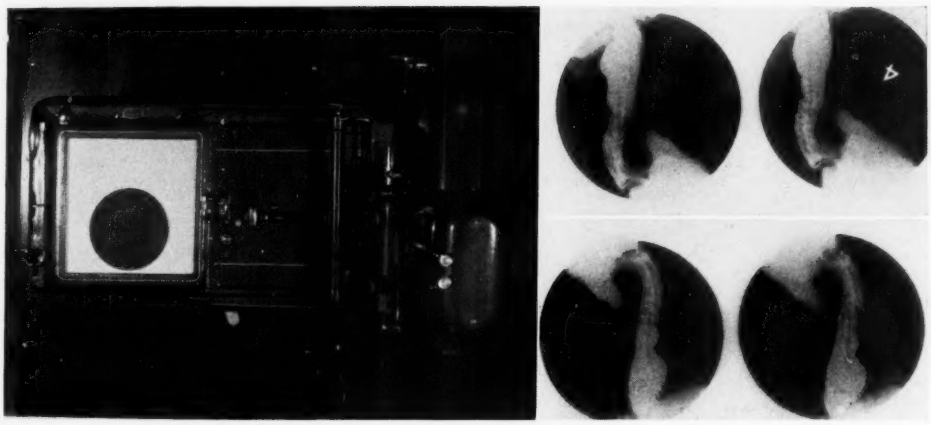


Fig. 1-*E*. Handle, *Y*, is moved to the left and the compression cone is in place. Handle, *Z*, is raised. Two spots are upside down on the film because the cassette is automatically inverted after the second exposure. The film shows the appendix and the normal terminal ileum (see Fig. 10).

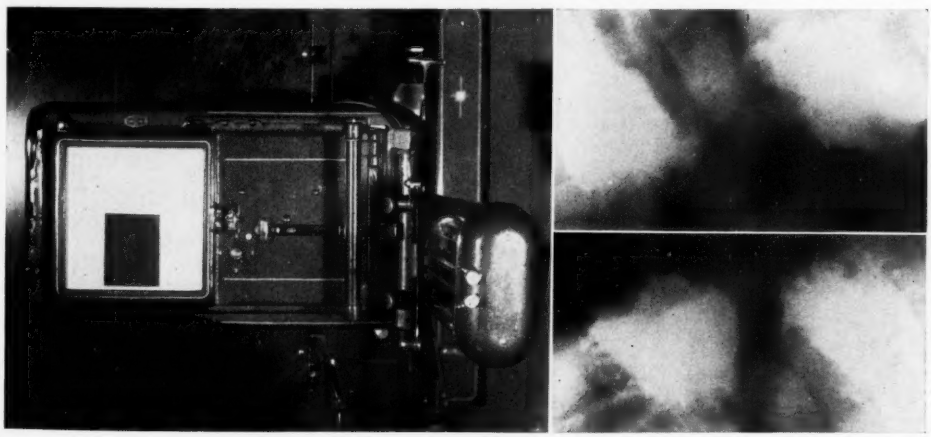
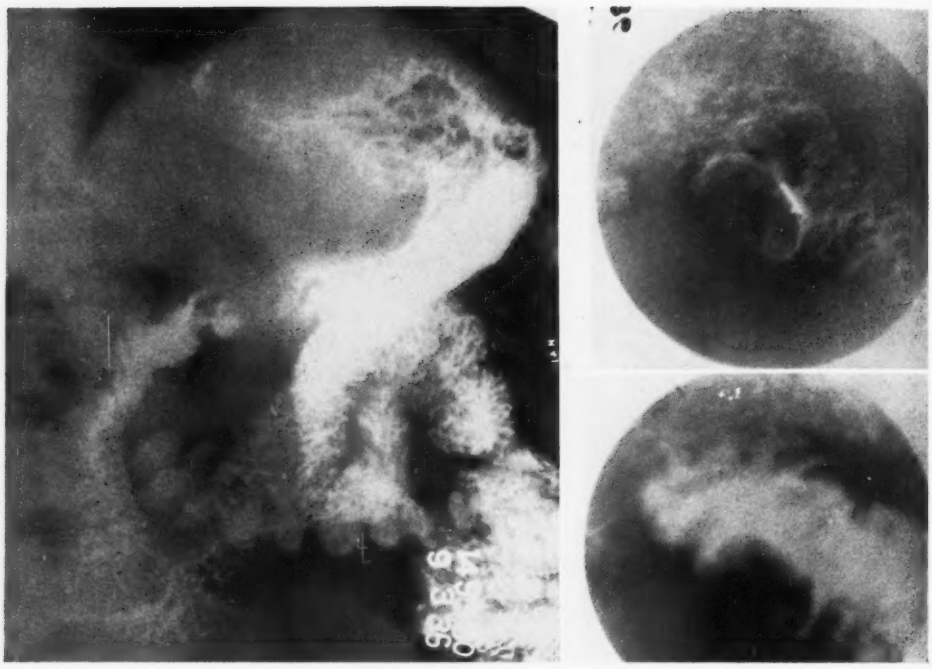


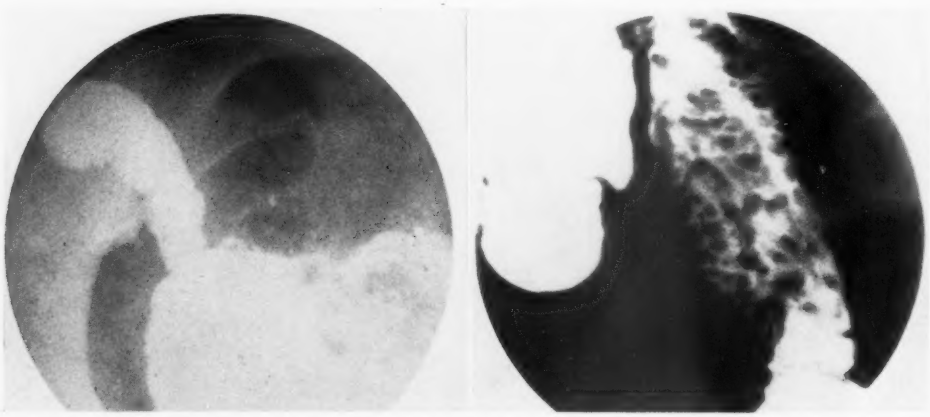
Fig. 1-*F*. The shutters are set for 4 × 5 inch non-compression fields. Handle, *Z*, is raised. The film illustrates this method of examination of the fundus of the stomach in various supine oblique positions. Combinations of the above can be made as desired.



A *B*

Fig. 2. Filling defects are shown in a duodenal loop but are shown better in compression films, *B*. The two small films show varying degrees of compression.

T. D. (Unit No. 497,074). A 52-year-old man complained of pallor, loss of strength, and slight dyspnea on exertion. He was known to have profound anemia, with achlorhydria, for several months, which had been treated by liver extract. Occult blood was found in the stools. Gastro-intestinal studies showed multiple defects in the lumen of the duodenum and small intestine suggesting masses in the wall of the gut. The larger of these masses involved the terminal ileum which may have been the primary site. Exploratory celiotomy showed multiple tumors, biopsy of which showed a malignant growth of "probable endocrinian origin. It was not a carcinoma, carcinoid, or adenomatous growth" (Stout). X-ray therapy was ineffective. Death occurred 37 days after operation.



A *B*

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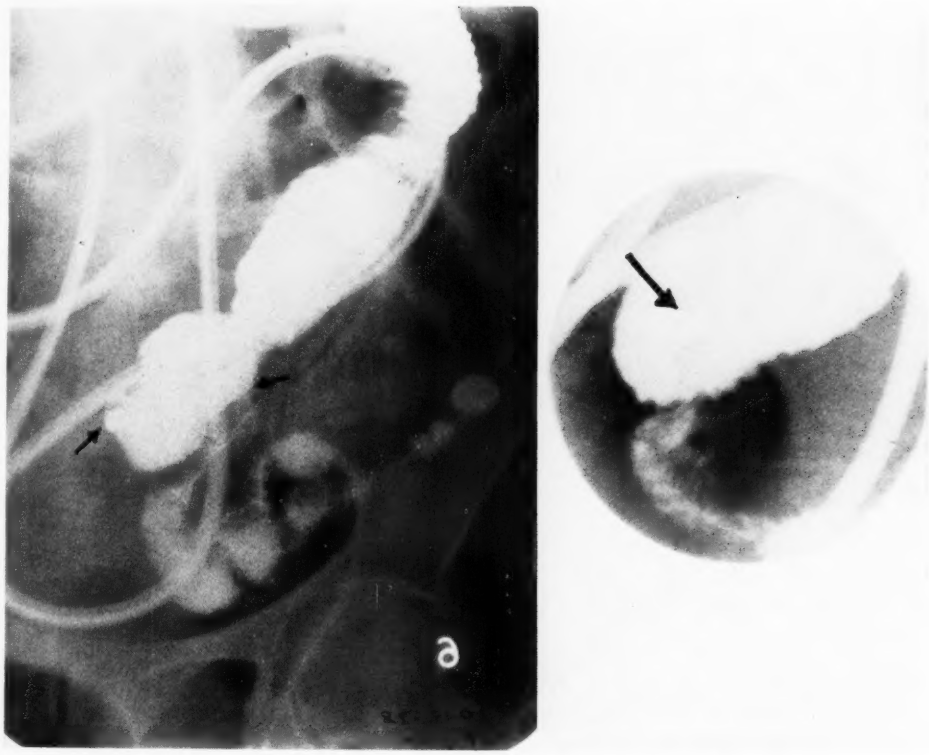
Fig. 3-*A*. Terminal ileum without compression.

Fig. 3-*B*. Terminal ileum with compression showing rounded areas of diminished density in the barium shadow suggesting polypoid elevations in the mucous membrane. The walls were flexible and the lumen was not diminished.

K. Y. (Unit No. 510,938). A 13-year-old girl complained of right lower quadrant cramps of two weeks' duration. There had been previous similar attacks during the past year without fever or diarrhea. A small intestine study showed the abnormal pattern in the ileum illustrated above. At operation the terminal 7–8 cm. of ileum were slightly thickened but the serosal surface appeared normal. Enlarged lymph nodes were present in the mesentery. The appendix appeared normal, but it was removed. Nothing was done to the ileum.



A *B*

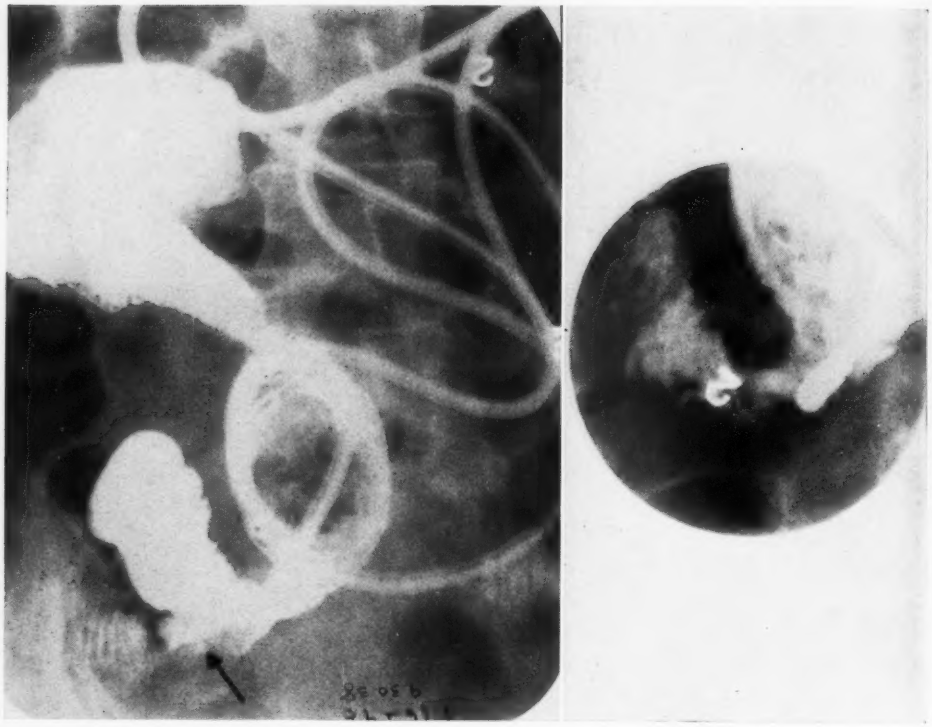
Fig. 4-*A*. Film showing obstruction from post-operative adhesions. A constriction in the small bowel lumen is present at the end of a Miller-Abbott tube. The tip of the tube, marked with an arrow, overrides the site of the obstruction. Compression film, *B*, brings the constriction into better profile.

D. L. (Unit No. 559,621). A 58-year-old woman developed obstruction of the small bowel on the third day after hysterectomy for carcinoma of the fundus uteri. There was immediate relief from Miller-Abbott tube suction. Roentgenograms showed the constriction to persist in spite of decompression. Operation showed adhesions of the bowel to the stump of the uterus. Recovery was complete.

without compression, in the examination of the esophagus, the small and the large intestine. The cases presented herewith have been selected to illustrate a method rather than pathologic processes.

APPARATUS

This type of apparatus consists essentially of two elements in addition to the usual fluoroscopic equipment. The first is a combination of fluoroscopic screen and cassette tunnel so arranged that the film can be quickly shifted into place in the beam of x-rays. Compression can be secured in a number of ways but the most convenient is a small cone attached to the



A *B*

Fig. 5-*A*. A constriction is seen in the small bowel lumen from post-operative adhesions.
Fig. 5-*B*. Compression film shows the constriction better than does Figure 5-*A* (non-compression film).
D. B. (Unit No. 560,491). Post-operative ileus developed in a woman aged 34, following acute appendicitis with abscess and spreading peritonitis. Subsidence occurred after decompression without operative interference. Adhesions were apparently present at the operative site.

screen-holding frame in such a way that it can be moved into the field without delay. The second element is a device for the instantaneous changing of the low fluoroscopic current to a sufficiently high roentgenographic current to permit an exposure of a quarter of a second or less, in the majority of cases.

The earliest machines developed in Europe for this purpose were arranged for the examination of patients in the erect position only. More recently, these devices have been attached to tilting fluoroscopic tables, which permit the use of compression in horizontal positions and the employment of the apparatus in more varied conditions. The various models now available differ somewhat in construction. The details of design are unimportant; much depends upon the skill and ingenuity of the worker.

In our experience, the use of a double focus tube—the small spot for fluoroscopy and the large for roentgenography—is undesirable. As observation of the filament ampere meter readily shows, it takes about two seconds to heat up a cold filament to the required temperature when the change from low to high current is desired. Exposure too quickly after the shift is made will result in an unsatisfactory film. While in some situations that much elapsed time is unimportant, in others it is too great to make the operator certain that he is getting what he wants. On the other hand, a filament hot enough

A *B*

Figs. 6-*A* and 6-*B*. Obstruction from secondary carcinoma in the wall of the small bowel. Constriction and pressure are seen from a growth in the bowel wall, shown best by pressure film, Fig. 6-*B*.
M. R. (Unit No. 550,180). A 66-year-old woman was found to have metastases to the small bowel and peritoneum from carcinoma of the ovary. The obstruction was relieved at operation. The patient is doing well six months after operation, gaining weight, with normal activities.

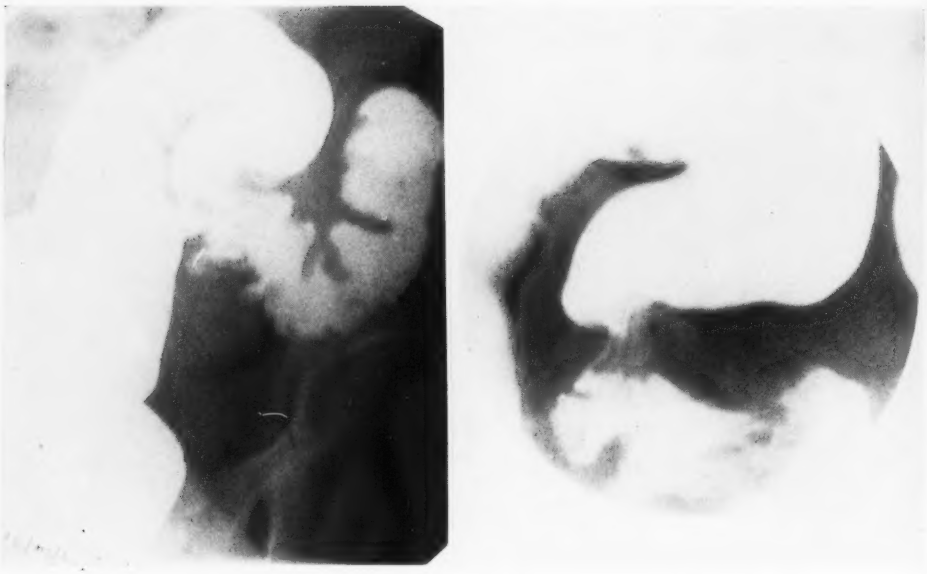
for fluoroscopic current will reach the temperature required for roentgenography almost instantaneously when the shift-over is made.

The device employed by the writers is illustrated and described in Figures 1-*A*–1-*F*.

It seems economical of both time and material to make four compression spots on one film, inasmuch as almost invariably more than one, often several, exposures are necessary to be sure that a certain significant shadow can be reproduced. The use of smaller separate films requires more time in handling, more material in the way of small cassettes, which cannot be used for other purposes, and involves limited application of the device.

The 10 × 10 inch fluorescent screen was selected after some observations on the standard 12 × 16 inch screen indicated that the field necessary for study of the *gastro-intestinal tract* very rarely exceeded ten inches in either direction. However, this size of screen, in our opinion, is not large enough for a thorough study of the chest. It is not wide enough for a satisfactory comparison of the movement of the two sides of the diaphragm or the inflation and deflation of the two lungs.

This device has a circular compression cone 4 in. in diameter which can be moved into place behind the screen. Compression cones of other sizes and shapes could easily be adapted. Without compression, this and other similar devices may be used during fluoroscopy for quick exposures with fields of various shapes and sizes (Fig. 1). The entire 8 × 10 in. film may be conveniently used to record a gastric residue or the appearance of the



A *B*

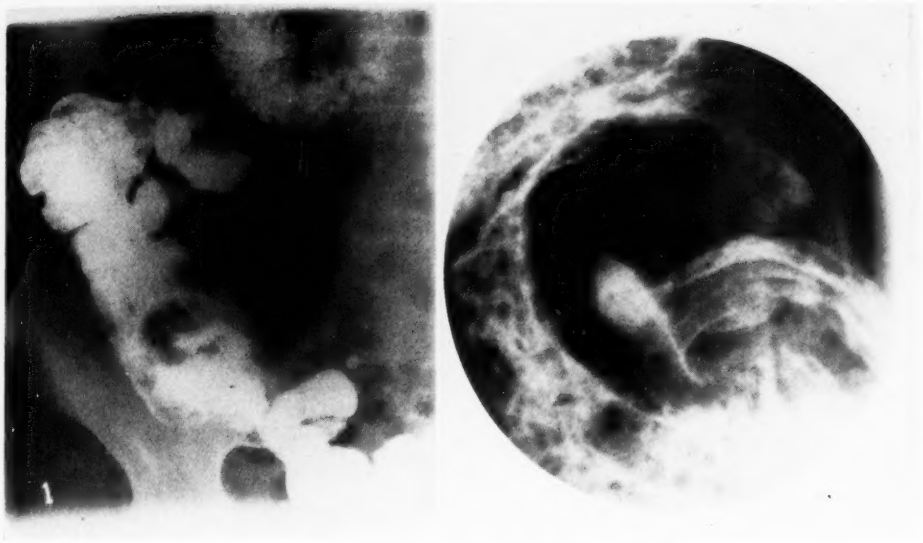
Fig. 7-*A*. An obstructing lesion was found in the sigmoid due to an intramural endometrioma.
Fig. 7-*B*. Compression film showing mucosal contours running through the constriction and a smoothly rounded indentation adjacent to it due to pressure from the intramural growth. These details can be appreciated only on the compression film.
I. D. (Unit No. 509,626). A 44-year-old woman complained of increasing constipation for two months, which terminated in complete obstruction. There was no weight loss. She had been married seven years with no pregnancies. There was operative proof of the endometrioma. A transplant was found in the wall of the sigmoid. The mucosa was intact. There was complete recovery after bilateral oophorectomy and partial colectomy

sigmoid with the patient rotated to the left or right during a barium enema. Two fields, 4 × 10 in., or even three, about 2.5 × 10 in., are suitable for a rapid succession of exposures of the esophagus with different degrees of filling. Small sections of the gastro-intestinal tract—for example, the fundus of the stomach—in various supine oblique positions, may be studied on four rectangular 4 × 5 in. fields. The antrum of the stomach or portions of the small intestine may be recorded on two 5 × 8 in. fields. It is hardly necessary to remark that exposures made in this way at the right moment during fluoroscopy frequently give helpful information.

It must be borne in mind that the use of any compression device introduces two variables in exposure factors, while in standard roentgenographic technic there is only one, *viz.*, thickness of the part. The second factor is the changing target–film distance as the device is moved in or out. As compression is instituted, the thickness of the portion of the abdomen through which the rays pass is diminished and the target–film distance is shortened. As the patient is turned to an oblique position, the target–film distance, as well as the thickness of the part, increases. It is obvious that the object–film distance should be maintained invariably as short as possible to secure the best definition of the shadows.

CLINICAL APPLICATIONS

The rapid switch-over apparatus, both with and without compression, has, in our experience, been helpful in the examination of portions of the gastro-intestinal tract aside from the stomach and duodenal bulb.



A *B*

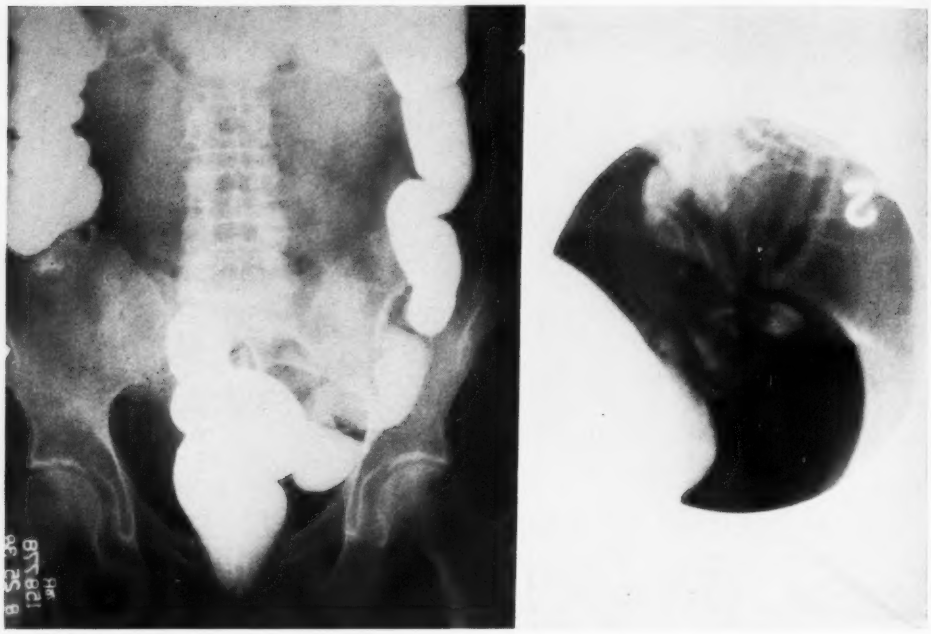
Figs. 8-*A* and 8-*B*. Details of intussusception at the ileocecal valve, shown better on compression film, 8-*B*. N. L. (Unit No. 559,652). A woman, aged 56, complained of intermittent crampy pains in the lower abdomen of several months' duration. Operation showed an intussusception provoked by hypertrophy of the ileocecal valve ring. An ileocolostomy was done near the ileocecal valve (side-to-side anastomosis), with relief of symptoms.

Esophagus.—The esophagus may be easily examined in either the horizontal or erect position. The horizontal position removes the effect of gravity and slows the passage of the opaque material which must then be propelled by contraction of the muscle. The patient may lie either prone or supine and may be rotated to the right or to the left. The diaphragm is narrowed to make a field 4 × 10 in. or 2.5 × 10 in., depending upon whether the observer wishes to make two or three exposures on the fi'm (Figs. 1-*B* and 1-*C*). As the opaque material is seen to reach the required position, the film is switched into place and the exposure is made. The second exposure can follow as soon after the first as seems desirable—one second later, if necessary. A quick succession of exposures with different amounts of barium remaining in the esophagus is useful in studying the mucosal pattern, especially in the search for varices.

Small Intestine.—The mucosal pattern of the jejunum is usually well shown without special effort. The mucosal folds of the lower ileum, however, are low and the volume of barium in the lumen often obscures them. Compression films show clearly the mucosal pattern (Fig. 1-*E*). We have seen some cases of ileitis in which the lumen was not narrowed and compression films disclosed rounded areas of diminished density in the barium shadow, suggesting polypoid elevations on the surface of the mucous membrane. Two of these cases (Fig. 3) were operated upon and were found to have slightly thickened walls In neither case was resection necessary and, consequently, a histologic diagnosis is not available.

In some patients, portions of the lower ileum lie so far down in the pelvis that compression cannot be applied. By rotating the patient, overlapping coils may be separated and non-compression exposures obtained with the necessary field size in the optimum position.

Intestinal obstruction and paralytic ileus, but not mesenteric vascular occlusion which requires immediate operation,



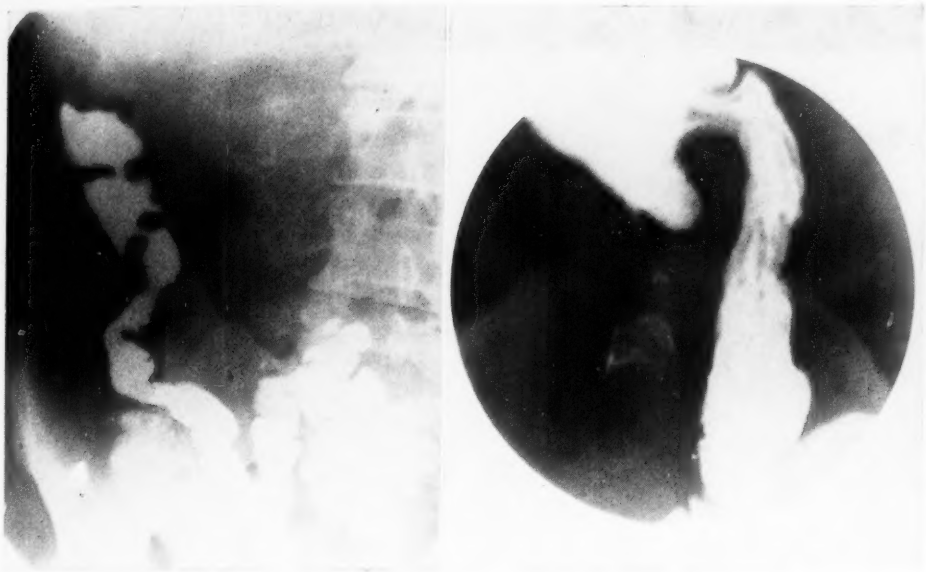
A *B*

Fig. 9. A diverticulum is present in the sigmoid demonstrated only by compression. 9-*A*. Routine barium enema film; 9-*B*. Pressure film.

are now being routinely treated by deflation with the Miller-Abbott tube (4, 5). Without going into detail, from the diagnostic standpoint, the great advantage of the method is that it permits the exact localization of the obstruction. When the balloon ceases to advance, a little barium suspension is injected through the tube with the patient on the fluoroscopic table, which will show whether or not an obstruction is present below the tip and will give information as to its nature. In some cases the point of obstruction is superimposed upon the dilated, barium-filled proximal portion in such a way that the narrowed area is obscured. With the compression cone, the superimposed loop or loops can be displaced and the narrowed area brought into profile; in some cases an end-on view is changed to a side view. The detail shown on the compression film assists in distinguishing neoplasm, inflammation, and constriction by adhesions. If dilated, flexible intestine without a constriction is demonstrated beyond the tube tip, the adynamic nature of the ileus is apparent (Figs. 4, 5, and 6).

Large Intestine.—The switch-over device without compression is frequently used to make an 8 × 10 inch film of the recto-sigmoidal junction and pelvic colon during a barium enema as the sigmoid fills with the patient rotated toward the left. A similar record of the hepatic or splenic flexure with the patient rotated so as to separate superimposed loops is sometimes desirable (Fig. 1-*A*).

The compression cone is sometimes useful. In one instance, a constricting carcinoma of the sigmoid was clearly shown on compression films when the cone had displaced the overlapping adjacent portions. In one case, the persistence of mucosal folds in a sigmoidal constriction was clearly shown only on compression films (Fig. 7); adjacent to the constriction



A *B*

Fig. 10. A fecalith is present in the appendix, first thought to be a calcifying lymph node in the mesentery until detail films showed its connection with the lumen of the appendix. 10-*A*. Routine six-hour gastrointestinal film; 10-*B*. Pressure film.

was a rounded impression in the wall due to an intramural endometrioma. In another case, a filling defect around the ileocecal valve was shown more distinctly by pressure (Fig. 8). Diverticula are sometimes shown better by compression (Fig. 9).

Appendix.—In some cases, it is difficult to identify the appendix shadow on the usual 24-hour film. In three instances, pressure films have assisted in showing the appendix and have given details concerning its lumen which were not otherwise available (Fig. 10). In one case, a kink immediately adjacent to a large fecalith was evident only on the pressure films.

We do not make pressure films of the appendix as a routine, but believe it advisable in any case with right lower quadrant pain or tenderness, or if a clinical question of appendiceal disease has been raised.

CONCLUSION

A rapid switch-over device for making roentgenograms on a tilting fluoroscopic table is a useful addition to the roentgenologist's equipment. Its usefulness in the examination of the stomach and duodenum has been attested by numerous workers. In regions other than the stomach and duodenal bulb, both with and without compression, helpful information, difficult to obtain in other ways, may be secured by this method.

Because of accurate fluoroscopic centering and delimitation of the field, special studies of small areas may be made with maximum economy of material. Without compression, it has been helpful in examining the esophagus, particularly for varices. In the small intestine, particularly in certain cases of ileitis and in intestinal obstruction after the insertion of the Miller-Abbott tube, compression films have given valuable information. Compression is less frequently necessary in the study of the large intestine, but the ease with which this type of device can be used for non-compression exposures in selected

positions, leads to frequent, almost routine use with the barium enema.

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SOME USES OF THE SPOT FILM IN THE ROENTGEN-RAY EXAMINATION OF THE GASTRO-INTESTINAL TRACT[1]

By JOSEPH C. BELL, M.D., *Louisville, Kentucky*

IN THE past there has been considerable difference in the opinions of roentgenologists as to the value and importance of various methods of examination in the diagnosis of pathologic lesions of the gastro-intestinal tract. To-day, however, most experienced and well informed examiners will agree that the spot film has a definite place in quite a high percentage of such examinations.

The spot film as an adjunct to the usual film technic in gastro-intestinal examinations was largely developed by European investigators, and the apparatus and technic for making such films were developed there. The historical background of this work has recently been reviewed very completely by Holmes and Schatzki (1). In this country Boman (2), Geyman (3), Cole (4), and Holmes and Schatzki (1) have emphasized the importance of this work and have made original contributions to the technic of examination.

An obstacle to the general use of the spot film in gastro-intestinal examinations in this country has been the lack of suitable apparatus that is readily adaptable to that in use, although both Boman and Geyman have described apparatus that has given excellent results in their hands. It has been toward the solution of this problem that I have directed some of my efforts during the past seven years.

The essential additions to the apparatus already in use in any well equipped roentgen-ray department are a quick change-over switch for rapidly changing from the fluoroscopic to the radiographic setting and for making film exposures, a serial film tunnel with provision for localized compression of the part being examined, and a locking device which will automatically maintain any desired degree of compression. I have developed such additional apparatus and have used it for sufficient time to know that it is satisfactory in all respects. The basic principles employed are, in most instances, adaptations of those previously described by others.

The quick change-over switch was described in an article published in 1935 (5). It has been used as described without change or repair and with complete satisfaction since the Summer of 1934, when it was completed. The serial film tunnel now in use is the last of a series of seven different ones that were built. This one was constructed in the Fall of 1936 and was described in an article published in May, 1937 (6). It has been used without change, except for a minor one in the locking device, since that time and has given entire satisfaction. The locking device now employed was described in the same communication as the film tunnel.

The spot film supplements but does not replace films made in the usual manner. In my work I routinely make a film in the right postero-anterior oblique position, with the patient supine and rotated toward the left. The film is made after fluoroscopic localization by placing the cassette on the patient's abdomen, after which the exposure is made, with the quick change-over switch and the fluoroscopic tube. Such a film is illustrated in Figure 2. It is of value in showing the fundus of the stomach filled with opaque material and also usually gives an excellent double contrast view of the mucosa of the distal two-thirds of the stomach and the duodenal cap. Ulcer craters and other abnormalities may be shown in the latter areas by this means. Hampton (7) has

[1] Presented before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

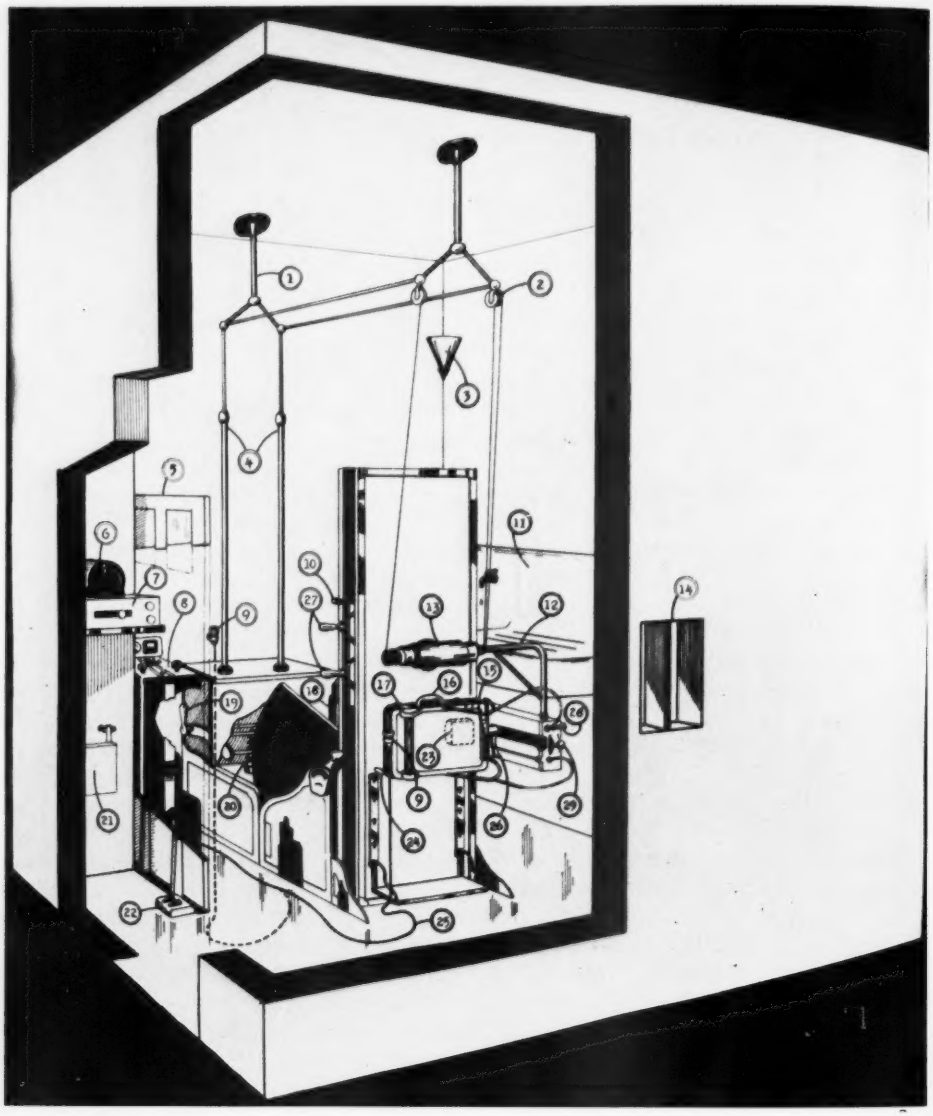

Fig. 1. Plan of room in writer's office where gastro-intestinal examinations are done. There are provisions for compression technic, serial radiography, and for making films of the ordinary type with either the fluoroscopic or radiographic tube. The numbers in the illustration indicate the following parts of the apparatus: (1) High tension bracket; (2) high tension reels; (3) indirect lighting fixtures; (4) high tension insulators; (5) operator's protective screen; (6) timer; (7) one of the two Coolidge choke coils (the other is in the control cabinet); (8) control; (9) exposure button for quick change-over switch when tunnel is not being used; (10) serial film tunnel with which serial films of ordinary type are made; (11) sink; (12) radiographic tube arm; (13) radiographic tube; (14) pass box to dark room; (15) lock to fix screen parallel to table top; (16) handle attached to spot film tunnel; (17) hangers for supporting spot film device on fluoroscopic screen; (18) fluoroscopic x-ray tube; (19) throw handle of high tension knife switch; (20) high tension transformer; (21) spot film tunnel shown where it rests when not in use; (22) foot switch; (23) compression or palpator apparatus on spot film device (portal in serial tunnel is 3.25 in. square; compression apparatus is a hemisphere approximately three in. in diameter); (24) handle for shifting cassette carrier in spot film tunnel; (25) exposure switch and cable of quick change-over switch shown in position occupied when spot film tunnel is not used; (26) compression lock; (27) handles for shifting film in serial tunnel; (28) lock for tube and screen when adjusting them parallel to table top; (29) lock for fluoroscopic screen when adjusting it vertical to table top.

recently emphasized the value of this position in demonstrating bleeding duodenal ulcers.

The film described above is followed by one made in the left postero-anterior oblique or direct lateral position with the

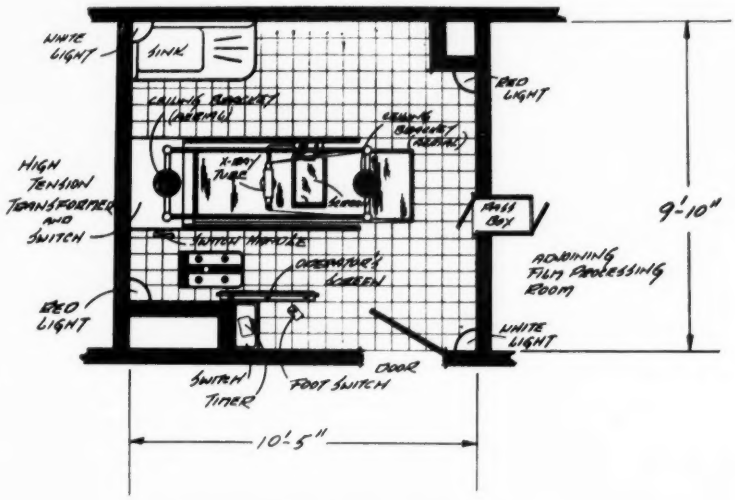

Fig. 1-*A*. Floor plan of gastro-intestinal room.

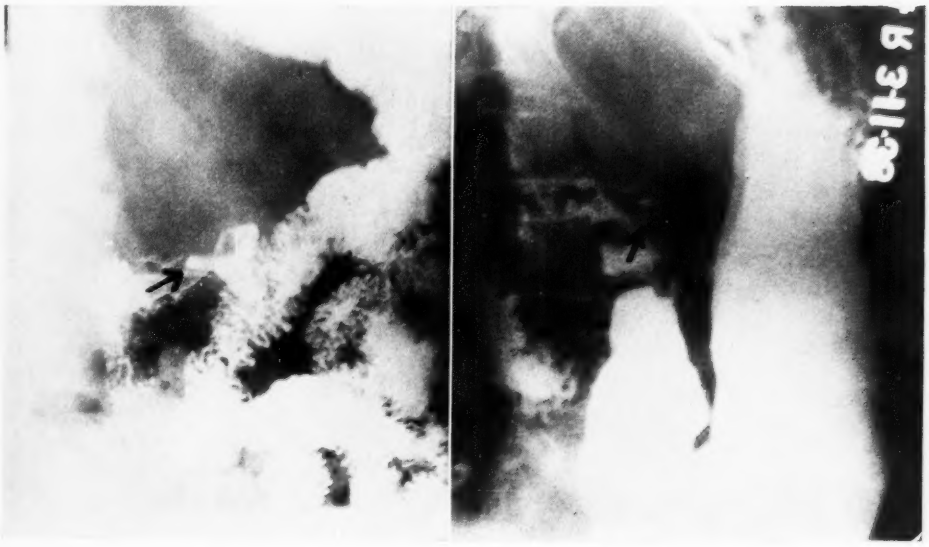

Fig. 2. Fig. 3.

Fig. 2. First of series of films that are routinely used in upper gastro-intestinal examinations. Film made in right postero-anterior oblique position with patient horizontal and rotated to the left. Quick switch and fluoroscopic tube used in making exposure. Niche of duodenal ulcer shown in middle third of first portion of duodenum.

Fig. 3. Second position routinely used. Film made in left postero-anterior oblique position with patient horizontal and rotated to the right until the first portion of the duodenum lies dorsal to the body of the stomach. This position is of value in showing which wall of the duodenum is involved when an ulcer is present.

patient horizontal. This type of film is illustrated in Figure 3 and is of value in determining which wall of the duodenum is involved when ulceration is present.

These films are followed by serial ones, generally eight in number, ordinarily made in the right postero-anterior oblique position with the patient prone. Centering is done by fluoroscopic control and the exposures are made using a tube mounted over the table, a special serial film tunnel mounted under the table top, and the quick change-over switch above mentioned. Although these serial films are routinely made to show the distal two-thirds of the stomach and the duodenum, if abnormalities are detected in other portions of the gastro-intestinal tract they may be shown equally well by this method. The apparatus used in this work was described in an article published in February, 1935 (5). It has proven to be most useful in my hands and I have found no other method that will replace it in the work for which it is being used. Films made in the latter manner are illustrated in Figures 4 and 5. They are of the greatest value in determining whether or not the walls of the part being examined are flexible and whether or not an apparent defect is constant.

The above are the only films that are used routinely, but many others are made with the patient either upright or horizontal, when indicated by the fluoroscopic findings. It has been in the making of such films that the quick change-over switch has proven to be of greatest value. It is used, however, in all exposures of any part of the gastro-intestinal tract except those in which the Bucky diaphragm is employed.

Fig. 4.

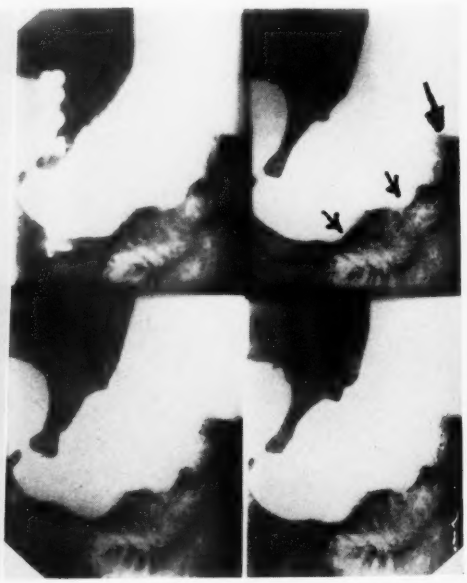

Fig. 5.

Fig. 4. Routine serial films of distal third of the stomach and duodenum made with the patient prone and rotated to the right. The quick switch, radiographic tube, and serial tunnel under the table top are used. The niche of a duodenal ulcer may be shown in films of this type when the first portion of the duodenum is almost empty, but when it is filled it may appear to be essentially normal, as is shown here.

Fig. 5. Serial films of the distal two-thirds of the stomach and the duodenal cap made in the same manner as those in Figure 4. The films show lack of flexibility in the greater curvature side of the distal third of the stomach. The variations from normal are not great and one might not suspect that pathology is present from these films.

Fig. 5-*A*.

Fig. 6.

Fig. 5-*A*. Spot films with compression, in same case as Fig. 5, show very large irregular filling defects in the distal third of the stomach characteristic of those seen in the presence of carcinoma. These filling defects were also noted during the fluoroscopic examination.

Fig. 6. Spot films showing a diverticulum of the middle third of the esophagus.

Fig. 7.

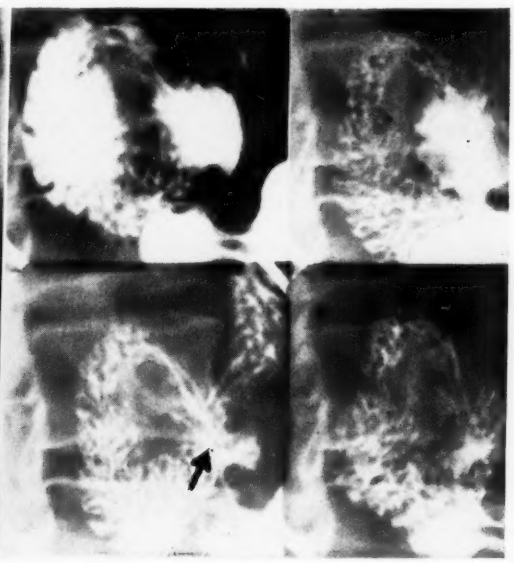

Fig. 7-*A*.

Fig. 7. A film made in the position described in Figure 2, showing an ulcer of the posterior wall of the middle third of the stomach located very close to the lesser curvature. The film also shows some deformity of the mucosal folds of the first portion of the duodenum with a shadow that is somewhat suggestive of the niche of a duodenal ulcer.

Fig. 7-*A*. Spot films of first portion of duodenum made with varying degrees of compression in the same case as Figure 7. Distortion of mucosal folds of first portion of the duodenum can be seen but a definite ulcer niche was not demonstrated.

Spot films are not used routinely but are made when the fluoroscopic findings indicate that they are advisable. I use them in approximately 50 per cent of my gastro-intestinal examinations and in approximately 60 per cent of the examinations of the gall bladder.

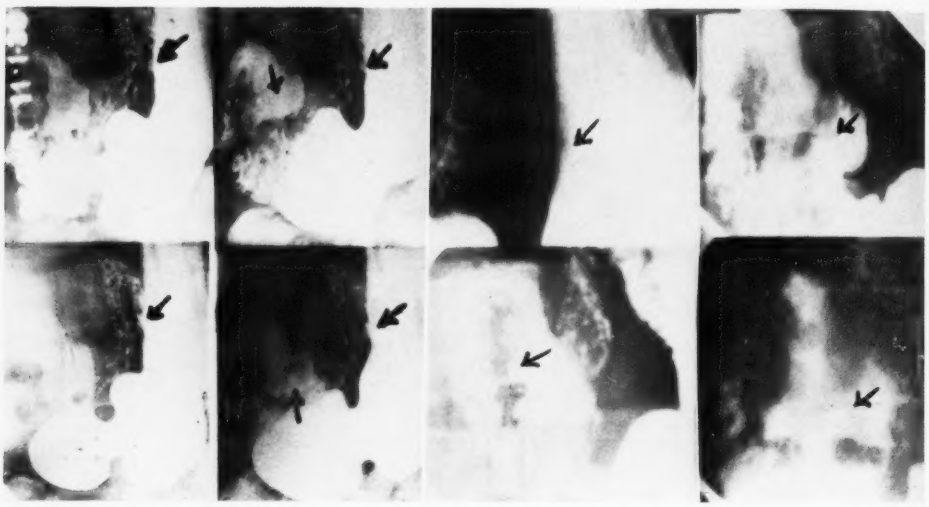

Fig. 7-*B*. Fig. 7-*C*.

Fig. 7-*B*. Serial films of distal two-thirds of the stomach and first portion of the duodenum made with the ordinary serial apparatus in the same case illustrated in Figures 7 and 7-*A*. The gastric ulcer previously shown is again demonstrated. A definite niche can be seen in the posterior wall of the first portion of the duodenum in the films made when that portion was almost empty.

Fig. 7-*C*. Spot films of middle third of stomach and first portion of the duodenum showing both ulcers demonstrated in Figure 7-*B*. The film in the lower left-hand corner was made in the left postero-anterior oblique position and shows the niche to be in the posterior wall of the first portion of the duodenum.

THE TECHNIC OF SPOT FILM RADIOGRAPHY

In Figure 1 is illustrated the general plan of the room and apparatus devoted to gastro-intestinal examinations in my office. This is shown for it seems wise to emphasize the importance of proper arrangement of equipment and space if one is to employ spot film technic when it is indicated. It is of utmost importance that the film tunnel be near the operator when not in use and that films be readily available in order that exposures may be made without delay when they are desired. Unless these requirements are satisfied, this type of examination may not be used when indicated, because of inconvenience experienced in the preparation for it.

The fluoroscope is used in the ordinary manner. A small amount of barium is spread over the mucosal surface of the part to be investigated and the mucosal relief is examined carefully. If a shadow is seen, indicating that spot films are desirable, the fluoroscopic shutter is closed to approximately the size of the opening in the film tunnel, the tube is centered directly over the area under suspicion, and the screen carrier is locked in this position. The tunnel is then suspended on the screen carrier and shifted to the right or left until the image on the screen and the opening in the tunnel coincide. The tunnel is not fixed to the screen carrier at its lower margin unless it is being used with the table horizontal, which is usually not the case. The shutter of the fluoroscope is then ad-

justed until the image extends just to the margins of the opening in the film tunnel. If compression is desired, the compression lock is placed in operation and the degree of compression desired, as determined by the fluoroscopic image, is made. The cassette is then shifted into place and the exposure made using a hand-controlled three-point pushbutton switch which rests in a clamp in the handle that is attached to the cassette carrier. This switch is so made that when the plunger is depressed it

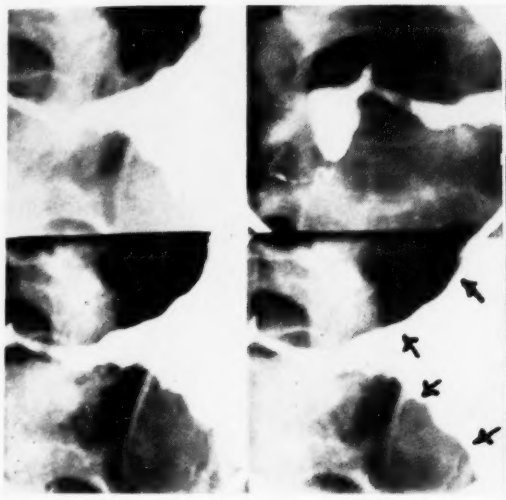

Fig. 8.

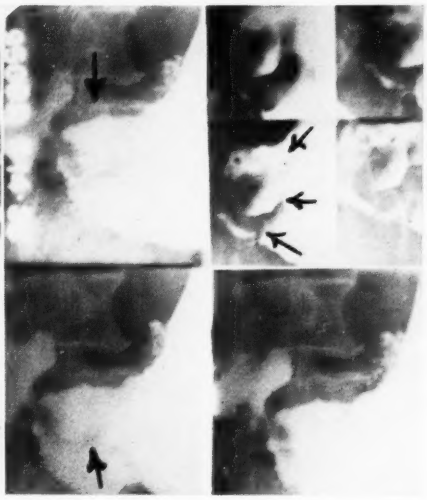

Fig. 9.

Fig. 8. Spot films of distal third of stomach and duodenal cap showing large scirrhous carcinoma of the stomach.

Fig. 9. All of the films except the four small ones in the right upper quadrant of the illustration were of the ordinary serial type. They show lack of flexibility in the lesser curvature side of the pyloric portion of the stomach and a shadow suggestive of ulceration. The spot films shown in the right upper quadrant of the illustration demonstrate a large growth involving the pyloric portion of the stomach in the center of which is a very large ulcer. The changes are those of a carcinoma with ulceration.

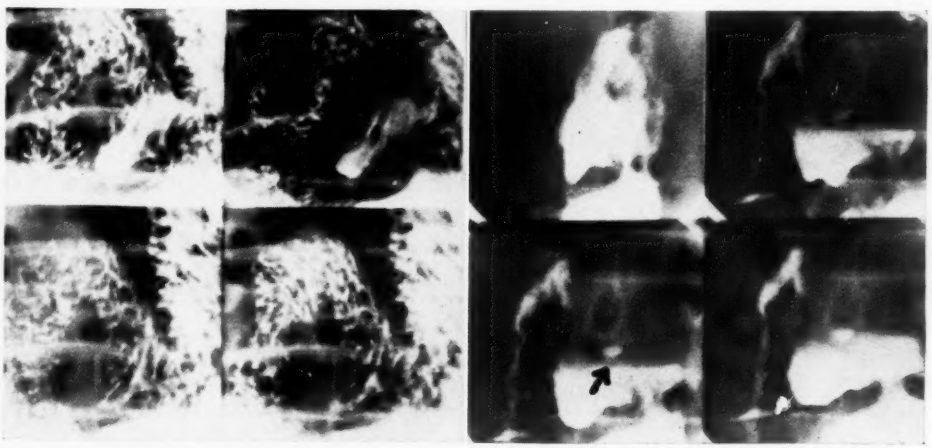

Fig. 10. Spot films of normal duodenal cap showing mucosal folds very satisfactorily.
Fig. 11. Spot films of first portion of the duodenum showing ulcer crater in posterior wall.

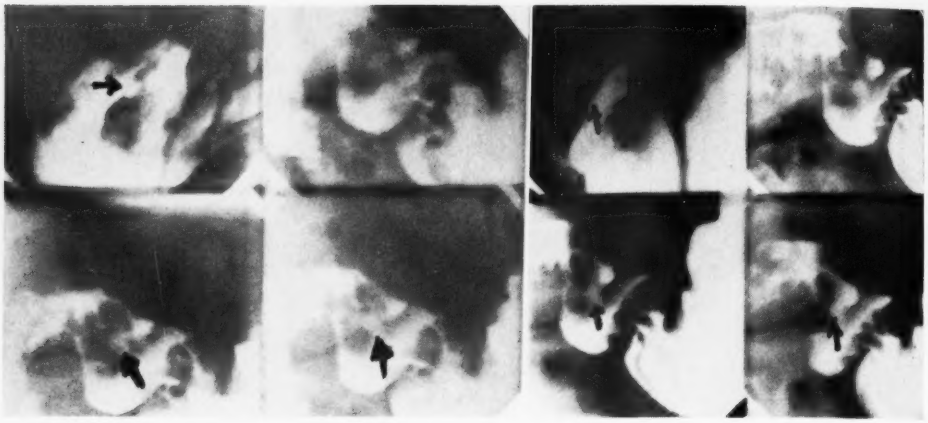

Fig. 12. Fig. 12-*A*.

Fig. 12. Spot films showing ulcer crater in posterior wall of first portion of duodenum. It is possible that the small dense shadow projecting from the anterior aspect of the middle third of the duodenal cap is due to a second niche. The illustration in the left upper quadrant was made in the left postero-anterior oblique position and shows the crater to be in the posterior wall of the middle third of the duodenal cap.

Fig. 12-*A*. Same case as shown in Figure 12. These exposures seemed to indicate that two ulcers were present, one in the anteroposterior and one in the posterior wall.

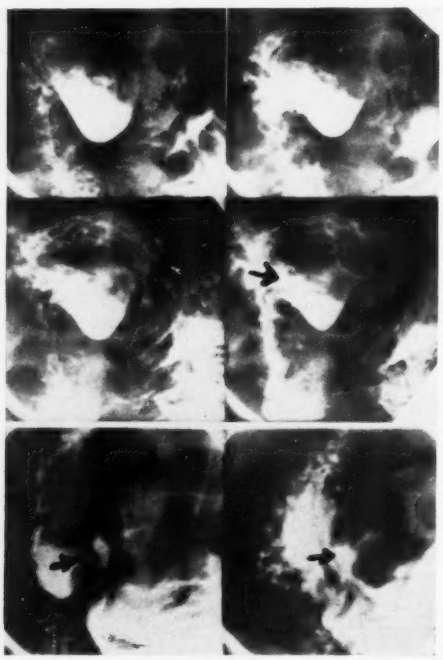

Fig. 13 (*top*). Spot films showing diverticulum of descending portion of duodenum.

Fig. 14 (*bottom*). Spot films showing niche of duodenal ulcer in base of first portion of duodenum just beyond the pylorus.

meets a point of resistance. When this point is reached the resistance in the primary circuit of the transformer has been cut out, one of the choke coils in the Coolidge circuit has also been cut out, and the setting of the machine has thus been changed from fluoroscopic to the radiographic. After an interval of an instant, which permits the cathode coil temperature to rise to the proper level for radiography, the plunger is completely depressed and the exposure made. The length of exposure is controlled by a timer in the circuit. The timer is usually set as the patient enters the examining room for, with a little experience, one can readily estimate the exposure needed.

A series of four exposures may be made with or without changes in the degree of compression or the compression may be released, the position of the patient changed, compression reapplied, and exposures made. When desired, the apparatus may be used to explore various fields of any part being examined, the field being changed with each exposure. In some instances more satisfactory films can be

made with the stomach completely filled with opaque material than can be done when only the mucosa is coated. The fluoroscopic findings usually indicate the time when spot films of the greatest value can be secured. Such films are usually made with the patient upright but the examination can be done equally well in the horizontal position, providing the part being investigated is in such a position that compression may be obtained if desired.

Fig. 15. Spot films showing niche of marginal ulcer located in stoma of gastro-jejunostomy. The mucosal folds of the stomach surrounding the stoma are larger and less sharply defined than is normally the case.

The control pushbutton of the quick switch can readily be removed from the clamp, for frequently the switch is used independently of the film tunnel. For example, if one sees anything with the fluoroscope that he wishes to record, it is necessary only to adjust the shutter so as to include the desired field, place the proper size film over the area to be exposed, set the timer, and then make the exposure.

The above operations may appear to represent a time-consuming, laborious procedure but such is not the case. My average time for the ordinary examination of the upper gastro-intestinal tract is ten minutes. This includes the fluoroscopic examination and making of the routine exposures above described. These are usually ten in number and if spot films are used, at least four more are made. I do not ordinarily note the time required for an examination, but one morning a short time ago I did six examinations of the upper gastro-intestinal tract in exactly one hour. Among these were two duodenal ulcers and one gastric carcinoma. An average of twelve exposures was made in each case, all of them being done by myself in the fluoroscopic room.

THE FIELDS OF USEFULNESS OF THE SPOT FILM

Of the lesions commonly found in the esophagus, only the diverticulum and the ulcer can be demonstrated to advantage by this type of film. Carcinomas, varicosities, the dilated esophagus seen with

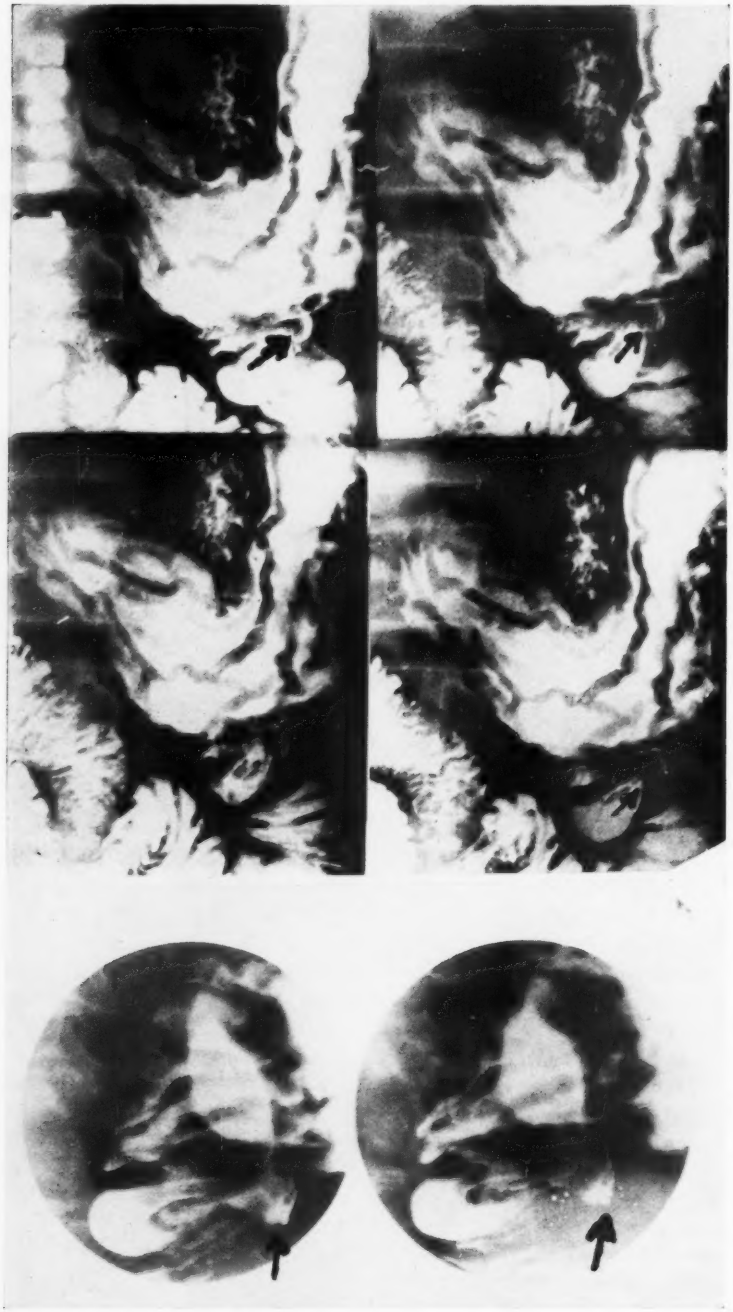

Fig. 16. Serial films made in the ordinary manner showing the mucosal relief of the stomach and proximal part of the jejunum in an individual with a gastrojejunostomy. The niche of a jejunal ulcer can be seen but was much more satisfactorily demonstrated in the spot films made with pressure directly over the niche. These are shown at the bottom of Fig. 16.

cardiospasm, etc., are usually shown much more satisfactorily by other methods having a larger field of exposure. In the case of the stomach, the mucosal relief may be well shown. Posterior wall ulcers away from the curvature may be demonstrated on such films when they cannot be shown by conventional ones, and the mucosa about the base of an ulcer may be visualized most satisfactorily. Early carcinomas, polyps, and small benign tumors may also be demonstrated well in this way. Large malignant tumors and large lesions of other types are usually better shown by other methods which provide for more adequate fields of exposure.

It is in the demonstration of the niche in duodenal ulcers that the spot film has proven to be of greatest value. The niche, when demonstrated, is proof positive of ulceration, past or present. It usually indicates that activity is present, although such is not always true. The niche is frequently

shown in conventional films but can be shown in a much larger percentage of cases by this method. The proper degree of compression and the proper technic are necessary to demonstrate the niche when present, however. Such films have value in following the progress of a duodenal ulcer, but after considerable experience with this and other methods of study in this disease I am of the opinion that the clinical symptoms are a better indication of activity or complete arrest of activity than are those of the roentgen ray.

The spot film is an excellent means for recording duodenal diverticula, benign tumors of the duodenum, and other lesions in this area. It is ideal for demonstrating a marginal ulcer in the stoma of a gastrojejunostomy or a jejunal ulcer. Such an ulcer as the one first mentioned is illustrated in Figure 15 and a jejunal ulcer is shown in Figure 16-*A*.

Many lesions of the small intestine and colon may be demonstrated to advantage by the spot film. This is particularly true of isolated polyps in the large bowel and of early carcinomas in cases in which the involvement is not extensive and is limited to one portion of the wall of the bowel. Most of the large lesions of the colon are better shown by other methods.

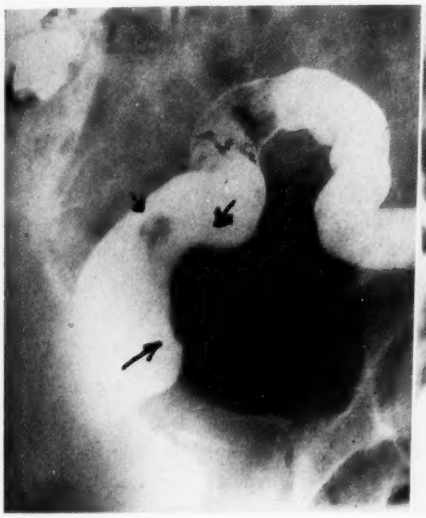

Fig. 17.

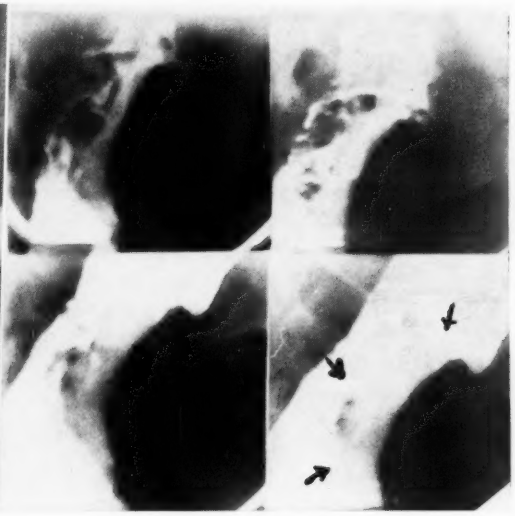

Fig. 17-*A*.

Fig. 17. A film of the rectum and sigmoid made in the right postero-anterior oblique position with the patient supine and rotated to the left. This film was made using the fluoroscopic tube and the quick change-over switch.

Fig. 17-*A*. Spot films of the proximal third of the rectum made in the same case as the film shown in Figure 17. These films show a large filling defect in the posterior wall of the proximal third of the rectum characteristic of the changes seen in the presence of a carcinoma. A carcinoma was demonstrated at the sigmoidoscopic examination.

COMMENT

The spot film should become an important adjunct to the film technic of many roentgen-ray examinations of the gastrointestinal tract and gall bladder. The necessary apparatus, readily adaptable to that already in use in any well equipped laboratory, can be built, or can be purchased from equipment companies at reasonable cost. This method of examination is not technically difficult or time-consuming and will amply repay the examiner employing it.

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THE VALUE OF THE UPRIGHT POSITION IN GALL-BLADDER EXAMINATIONS[1]

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SINCE 1928, various authors, particularly Sandström (8) and Åkerlund (1), in Sweden, and Bernstein (4) and Eliasz (6), in Germany, have recommended the x-ray examination of the gall bladder in the upright position. The credit for improvement of diagnosis and for the contribution of new physiologic data concerning the gall bladder is due mainly to these four men, but in only a few institutions has the examination of the gall bladder in the upright position become a routine procedure. It is my intention to demonstrate in this paper the value of this type of examination and to speak in behalf of its wider application.

First, let me say a few words in regard to technic. It is not the best procedure to take x-rays of the gall bladder simply with the patient in the erect position, although this alone may yield interesting results in some cases. It is preferable to focus the gall bladder by fluoroscopic examination in order to obtain the most favorable angle and the most favorable degree of compression for the roentgenograph in the upright position.

This type of examination can best be carried out by the use of the so-called "snapshot device," which was originally designed for taking exposures of the gastro-intestinal tract.

Before the improvement of diagnostic accuracy by this method of examination is demonstrated, some observations of normal cholecystograms will be discussed. If one looks at a cholecystogram of a normal gall bladder with the patient in the supine position, it usually appears to be of a fairly uniform density (Fig. 1-*A*). The same gall bladder in the upright position shows the fundus filled with a rather dense dye, while the upper half of the body of the gall bladder casts only a very faint shadow (Fig. 1-*B*). This observation indicates that the gall bladder must contain biles of different concentrations. Thus it is obvious that the rather hazy idea which we have concerning the contents of the gall bladder, namely, that liver bile flowing into the gall bladder most likely mixes with the concentrated bile already present in this organ, is erroneous. Figure 1-*B* shows that biles of various concentrations which do not mix can be present simultaneously within the gall bladder. This explains some observations of normal cholecystograms which were hitherto obscure.

A young woman, who complained of indefinite discomfort in the right upper quadrant and who was suspected to have gall-bladder disease, did not show any definite gall-bladder shadow 14 hours after double oral dye. After the fatty meal, however, a dense gall-bladder shadow was easily visualized (Figs. 2-*A* and 2-*B*).

It is only in the light of the previously discussed layer formation of bile that we can understand this peculiar phenomenon. Apparently the gall bladder of the patient was rather atonic and ptotic. Therefore, the layer of dye spread over a large area before the fatty meal and did not cast a satisfactory shadow. After contraction of the gall bladder, the lighter, non-contrast bile, *i.e.*, native, was eliminated, and the contrast, *i.e.*, iodine-containing bile, now forming a thicker layer in the contracted gall bladder, cast a shadow (Fig. 3).

According to Bernstein (4), one can actually observe the concentrating function of the gall-bladder wall if one makes films of the gall bladder shortly after the intravenous injection of dye. Bernstein

[1] Presented before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

(Fig. 4) observed a dense margin of dye outlining the contour of the gall-bladder wall 30 minutes after the injection of the dye. He interpreted this as a visual ex-

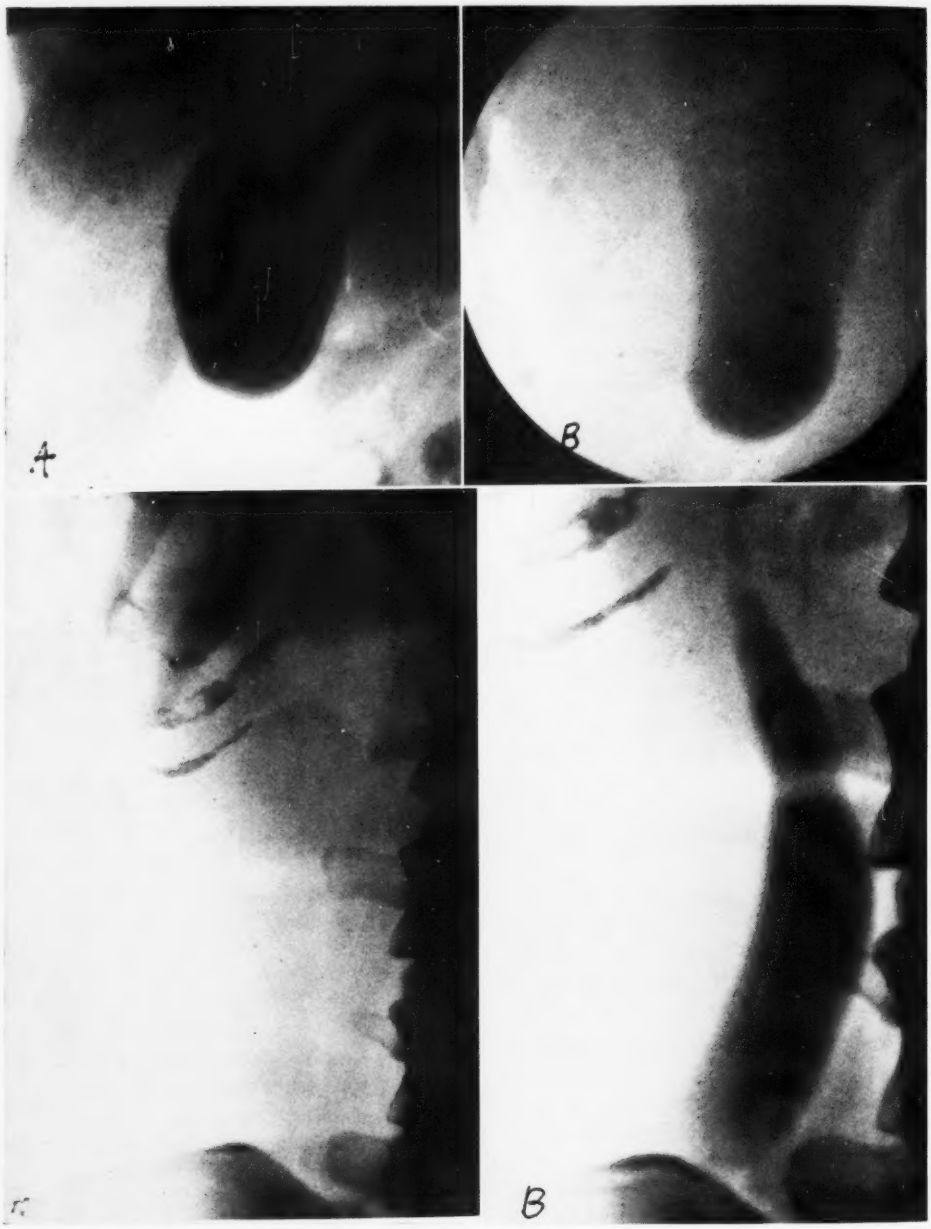

Fig. 1-*A* (*upper left*). Normal gall bladder in the prone position, apparently of uniform density.
Fig. 1-*B* (*upper right*). Same gall bladder in the upright position, showing dense dye at the lower pole of the gall bladder fading out toward the neck of the gall bladder.
Fig. 2-*A* (*lower left*). No definite gall-bladder shadow recognized before the fatty meal.
Fig. 2-*B* (*lower right*). Dense gall-bladder shadow visible outlining the contracted gall bladder thirty minutes after a fatty meal.

pression of the concentrating function of the mucous membrane, which obviously will first affect that portion of bile which is in immediate contact with it. A film made 50 minutes after injection demonstrated in a convincing manner that the heavy concentrated layer of bile does not fuse with the rest of the bile, but sedimentates and collects at the lower pole of the gall bladder. Later observations show that the concentrated contrast bile gradually rises from the lower pole until it nearly fills the entire gall bladder.

One of the diagnostic advantages of taking gall-bladder films in the upright position consists in eliminating any doubts which may arise as to whether an observed negative or positive shadow lies within the boundaries of the gall bladder or belongs to another organ. In fluoroscopy, it is

TABLE I.—SPECIFIC GRAVITY OF BILE IN NORMAL AND PATHOLOGIC STUDIES (ÅKERLUND)

Native Bile 1.010–1.040....	1.010 1.020	
Contrast Bile 1.030–1.085.. (iodine-containing)	1.030 1.040 1.050 1.060 1.070 1.080	Cholesterin stones in fresh, not dried, condition 1.040–1.058
Calcium Bile		Calcium-containing stones

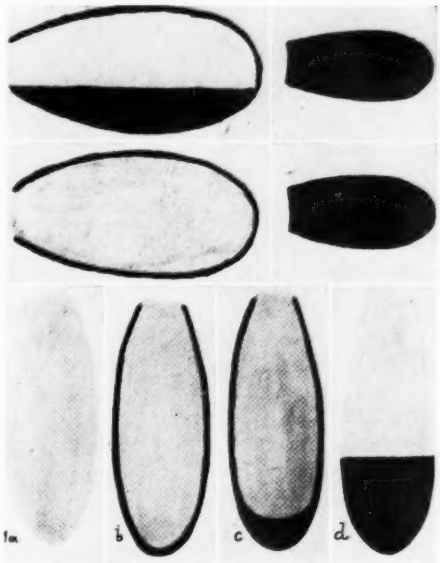

Fig. 3-A

Fig. 3-B

Fig. 4

Fig. 3-*A*. Gall bladder with layer formation if the film is made with the rays directed horizontally, before and after a fatty meal.

Fig. 3-*B*. The same gall bladder if the film is made with the rays directed perpendicularly, before and after a fatty meal. (Disregard the dense margin in Figures 3-*A* and 3-*B*, as it is only to emphasize the outline of the gall bladder.)

Fig. 4. Bernstein's diagram constructed from actual cholecystograms, taken in the upright position, showing the concentrating function of the gall-bladder wall and the development of layers of bile.

Fig. 5-*A*. Gall bladder in the prone position showing calcified shadows in the region of the gall bladder which cannot be differentiated from calcified cartilage.

Fig. 5-*B*. Same gall bladder in the upright position, showing calcified gallstones.

always possible to project the gall bladder free from such disturbing shadows. In Figure 5-*A*, it is difficult to say whether two areas of calcification in the region of the gall bladder belong to the cartilaginous costal arch or represent gallstones. The film in the upright position (Fig. 5-*B*) shows clearly that two gallstones are present. The same holds true for the question of gas bubbles or transparent stones.

It is also often instructive to know whether calcified stones which can be clearly seen without the dye test are freely movable or are impacted within the gall

Fig. 6. Cholecystogram taken in the upright position showing calcium carbonate stones collected at the lower pole of the gall bladder, and a single stone impacted in the neck of the gall bladder.

Fig. 7. Cholecystograms of a patient with two attacks of jaundice, the first without pain and the second with pain. The x-rays were taken during the second attack. (*A*) The gall bladder in the upright position shows a horizontal lower borderline instead of a rounded pole. This is due to a collection of tiny concretions without any dye between them. (*B*) At another angle the lower pole of the gall bladder can be seen outlined by a trace of dye. (*C*) The same gall bladder in the prone position showing no definite evidence of stones.

bladder. If the stones are free, they will definitely change their positions if examined in the prone and the erect positions. If a stone does not move, however, one can safely assume that it is impacted (Fig. 6).

Occasionally one meets a rather peculiar shape of the gall bladder in the supine position (Fig. 8-*A*). One has trouble in visualizing the anatomic configuration of such a gall bladder. In the upright position one recognizes a bi-lobed gall bladder, a congenital abnormality without great significance (Fig. 8-*B*).

The most outstanding information is obtained by the use of the upright position in cases of minute transparent stones. Many roentgenologists have had the disappointing experience of being unable to

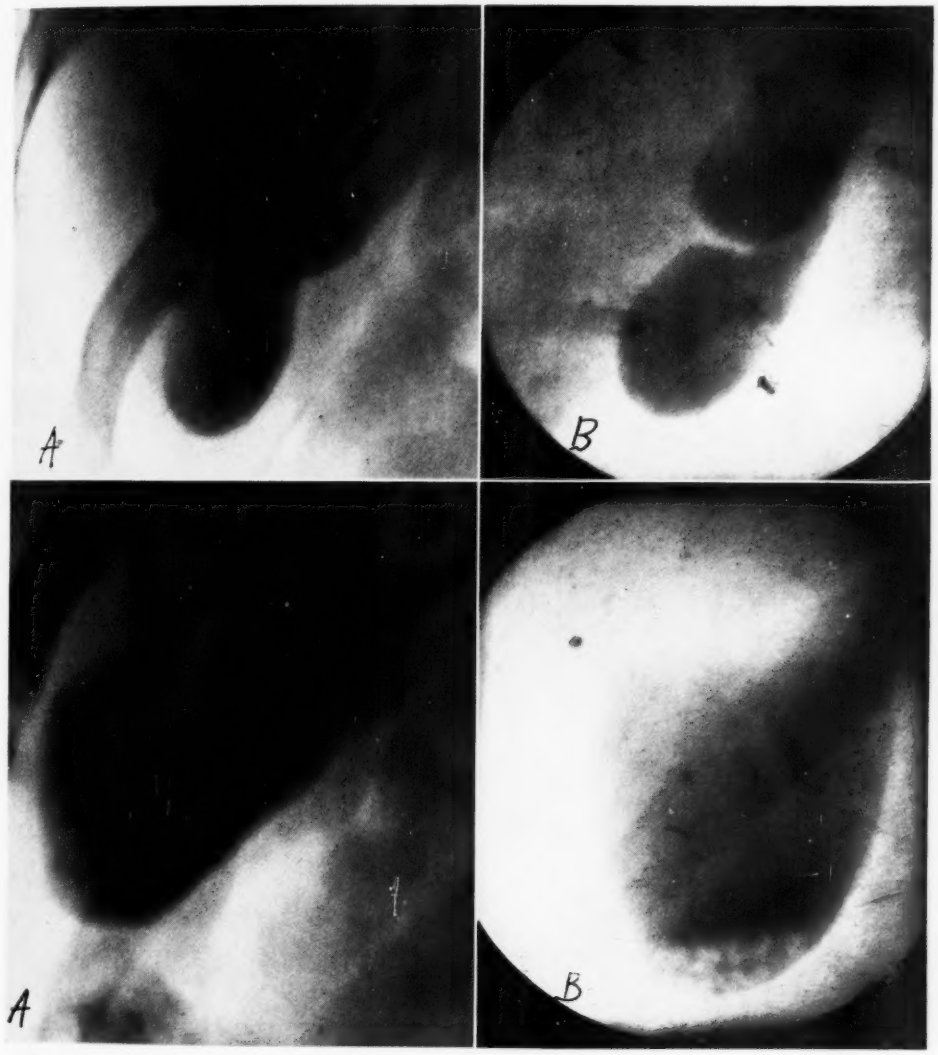

Fig. 8-*A* (*upper left*). Peculiarly shaped gall bladder in the prone position.
Fig. 8-*B* (*upper right*). Same gall bladder in the upright position, showing a bi-lobed appearance.
Fig. 9-*A* (*lower left*). Only suspicion of stones in the prone position.
Fig. 9-*B* (*lower right*). Definite small stones settled at the lower pole of the gall bladder in the upright position

demonstrate small stones in patients who had typical attacks of gall-bladder colic, and in whom surgery demonstrated numerous stones. It is in such a group of cases as this in which the supine position may show nothing at all, or only soft indefinite mottling. In these cases the small stones will easily show up at the lower pole of the gall bladder in the upright position and eliminate any doubt (Figs. 9-*A* and 9-*B*).

A picture similar to Figure 9-*A* is often obtained in cholecystography if duodenal air is overlying the gall bladder shadow. If the mottling is due to such air bubbles, the upright position shows clearly the absence of stones.

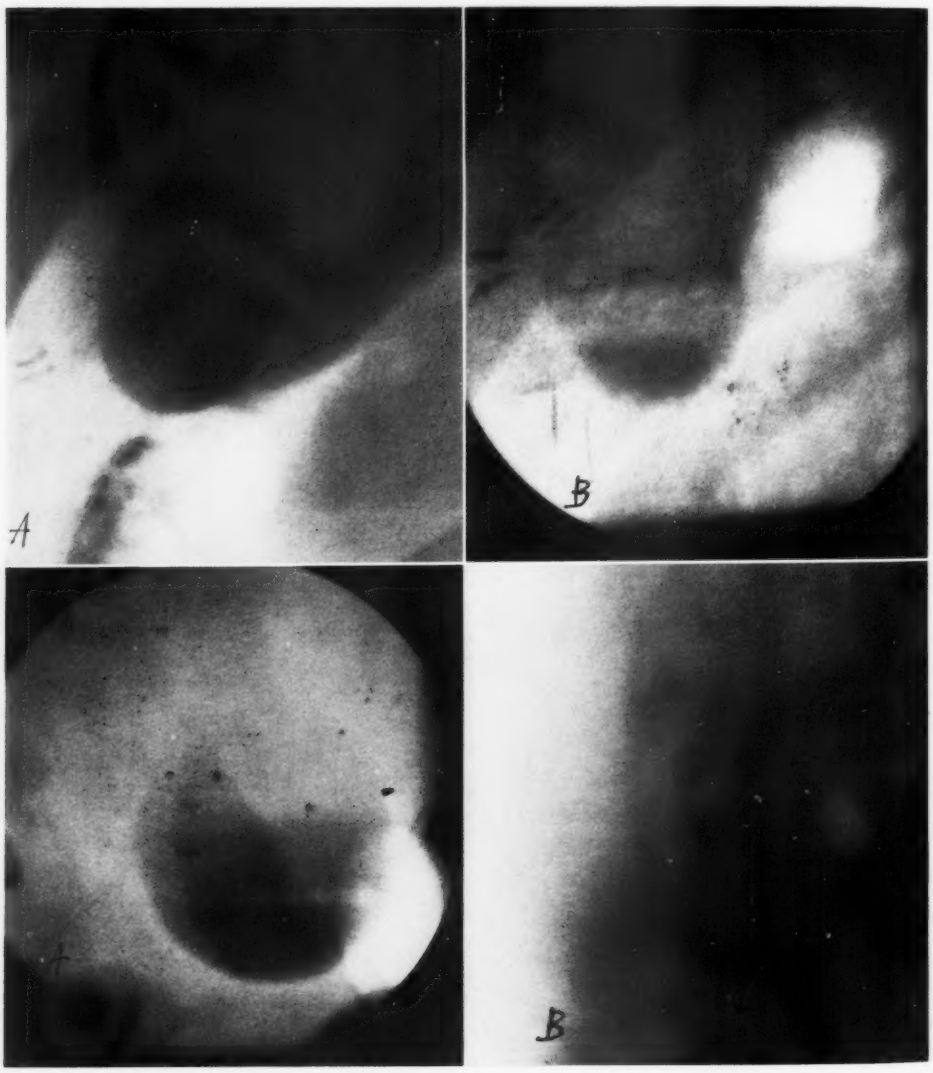

Fig. 10-*A* (*upper left*). Gall bladder in the prone position, showing no definite evidence of stones.
Fig. 10-*B* (*upper right*). Gall bladder in the upright position, showing numerous rows of stones.
Fig. 11-*A* (*lower left*). Gall bladder showing small floating stones five weeks after the onset of symptoms.
Fig. 11-*B* (*lower right*). Same gall bladder, showing increase in size of stones two years later.

Occasionally the concretions collect in such close contact to each other that they occupy the lower pole of the gall bladder completely, and only minute traces of dye penetrate between them. In such instances the gall bladder may appear as if suddenly cut off at its lower pole (Fig. 7-*A*). Only in certain angles does it become obvious that this peculiar appearance of the lower pole of the gall bladder is due to tiny stones (Fig. 7-*B*). The film made with the patient in the prone position did not show any definite evidence of stones (Fig. 7-*C*).

In a number of instances these small transparent gallstones are not found at the lower pole of the gall bladder, but are seen floating within the bile at various levels. This is by no means an extremely rare occurrence. In Figure 10-*A*, one would not suspect gall stones in the films taken in the supine position. The film made in the upright position (Fig. 10-*B*) shows numerous rows of stones floating at a certain level.

Considerable discussion about this phenomenon of "floating stones" has arisen in the literature, the main issue being whether the floating of the stones is due to the artificial conditions of cholecystography or whether one should conclude that small cholesterin stones can float in concentrated native bile. Åkerlund (2) is of the former opinion.

The following table (Table I), taken from a recently published paper by Åkerlund, contains the specific gravities of biles of different concentrations and of various stones, examined before they were dried by air. The specific gravity of even the smallest and lightest type of cholesterin stone is as high as 1.040. This, at the same time, represents the greatest specific gravity which native bile ever reaches. Higher specific gravities are present only in iodine-containing biles. It seems out of the question, therefore, that stones could ever float in native bile. There seems to be only one exception—gas-containing gallstones, which have only recently come to our attention in x-ray examinations (3, 7).

The "floating stones" represent stones of rather recent origin, this fact being borne out by the observation of their comparatively rapid growth in addition to the short history of the patients. If one reexamines cases of "floating stones" at a

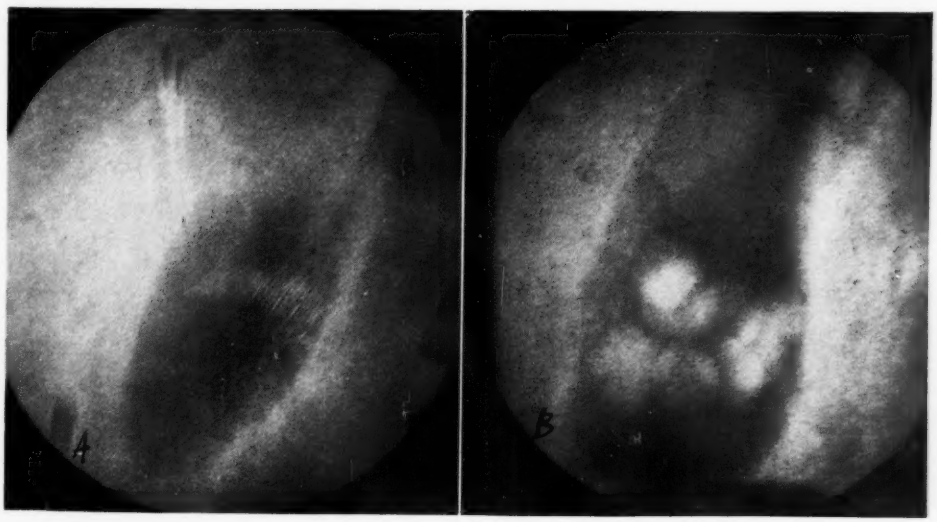

Fig. 12-*A*. Gall bladder showing small floating stones six months after the onset of symptoms.
Fig. 12-*B*. Increase in size of the stones shown eighteen months later.

later date, one finds a considerable change in size (Figs. 11-*A*, 11-*B*, 12-*A*, and 12-*B*).

Cases such as these seem to indicate clearly that the use of the upright position in cholecystography increases the accuracy of diagnosis and should be employed more frequently.

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POLYPS OF THE LARGE BOWEL[1]

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THE term "polyp" is general. It covers a variety of pathology which includes adenomas, fibromas, hemangiomas, papillomas, and inflammatory hyperplasia. However, radiologically, they are all seen as intralumenal shadows and present a potential hazard. Therefore, we, as radiologists, will define a polyp as "any pedunculated newgrowth arising from a mucous surface regardless of its histologic characteristics."

There are two types which are most commonly encountered. They are the adenoma and the pedunculated growth formed by hyperplasia of the mucous membranes. The etiology of polyps, as of newgrowths in general, is speculative. There are a few facts which are associated with the development of these types of newgrowths. Some of the polyps encountered in the large bowel are found concomitantly with inflammatory or ulcerative changes. These are not true newgrowths, but are either glandular hyperplasia or fragments of mucous membrane which have become infiltrated with leukocytes and plasma cells (Saint). Wesson and Bargen have shown in an analysis of 1,600 cases of ulcerative colitis that there is a 10 per cent incidence of these pseudopolyps.

Of the types of newgrowths, the adenoma is the most common. Dukes believes they arise from small areas of increased epithelial growth, and not from bulging lymphoid tissue which lies below the mucosa. He was unable to demonstrate signs of inflammation histologically in sections of true adenomas.

The literature regarding the frequency of polyps is based on autopsy series. Lawrence found 166 cases in 7,000 autopsies, or 2.3 per cent. Of the 166 cases, 95 show multiplicity of involvement. Susman, in a similar series of 1,100 autopsies, found 66 cases, or a percentage of 6. Of these, 27 showed multiple involvement. Stewart found 4.19 per cent in 1,850 autopsies.

Polyps occur more frequently in men than in women, with a ratio of 3 to 1. Table I shows the comparative percentages of the several investigators.

TABLE I.—SEX INCIDENCE

Sex	Lawrence	Susman	Saint
Male	76.4%	77%	74%
Female	23.6%	23%	26%

Polyps of the bowel is a disease of adult life; approximately 15 per cent occur before the fifth decade. It is rare in children. Lawrence, in 1,583 cases of children from infancy to the age of five, found one polyp. In 200 cases from the ages of six to ten, he found one polyp. Table II shows the relative percentages of the various investigators regarding the ages in which the polyps are most frequently found.

TABLE II.—AGE INCIDENCE

Decade	Lawrence	Susman	Saint
1	1.2%		
2	1.8%		
3	2.4%	1%	4.5%
4	7.2%	6%	13.6%
5	13.3%	18%	13.6%
6	25.0%	33%	20.5%
7	29.5%	36%	31.8%
7+	18.7%	8%	16.3%

One must not confuse this condition with polyposis coli universalis which is a disease occurring primarily in young adults. Doering found 80 per cent of these cases in patients under 40 years of age; Quenu and Landel 78 per cent, and Staemmler found 70 per cent in this age limit.

The adenoma is the most dangerous type of polyp encountered, since it is the opinion of most pathologists that adenomas are potentially cancerous and if given

[1] Presented before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

enough time all will become malignant. The coexistence of carcinoma and polyps has been amply demonstrated by several investigators. Dukes has shown the actual development of carcinoma in the tip of a benign adenoma. In 33 consecutive cases of carcinoma of the large bowel, he found 25 cases which showed polyps. In Susman's series of 34 cases of carcinoma of the colon, 15 showed coexistent polyps. In his series of 66 cases of polyps, 15 were malignant. In Lawrence's 166 cases, 3.6 per cent showed malignant changes. In 19 cases of carcinoma of the large bowel, he found 11.44 per cent associated with polyps. Saint found 13 cases of carcinoma associated with the 44 cases of polyps. In the statistics of Lawrence, he has shown that the age group for polyps and for carcinoma is approximately the same. However, the distribution of polyps is uniform, or almost uniform, throughout the colon; whereas the malignant lesions are found most commonly in the sigmoid and the rectum, indicating that the polyp is not the only precursor of carcinoma but is an important factor. Bargen states that there is an incidence of 25 per cent carcinoma in the pseudotype of polyp and makes the statement that the incidence of carcinoma in multiple adenoma is proportional to the number of polyps.

From the various statistics, it can be safely said that polyps do not have any predilection for any portion of the bowel. In Table III the frequency of the bowel sites involved is shown, as has been found by the various investigators.

TABLE III.—INCIDENCE IN NUMBER OF CASES OF BOWEL SITE INVOLVED

Bowel Site	Lawrence	Susman	Saint
Cecum	33		
Asc. Colon	35	42	14
Hepatic Flex.	5		
Tran. Colon	35	43	3
Splenic Flex.	10		
Desc. Colon	35	43	3
Sigmoid	43	33	20
Rectum	30	37	5

The clinical picture presented by patients with polyps is varied. When the history is characteristic, the cardinal symptoms are loose, frequent stools accompanied by gross blood. Careful inquiry into bowel habits of the patient will reveal periods of loose stools alternating with normal habits. This may go unnoticed by the patient for some time, due to the rather long periods of comparative freedom. They may also be passed off lightly as due to food indiscretions. The first appearance of blood in the stool causes more alarm. The patient then usually presents himself to the examining physician. However, this may even be subordinated if the patient has hemorrhoids or if the interval between hemorrhages is rather lengthy. Many patients are not seen until the diarrhea becomes unmanageable or an extreme inconvenience. Amebiasis may complicate the picture. Since this disease presents symptomatology similar to uncomplicated polyps, the latter may go unsuspected. The persistence of bleeding after adequate anti-amebic treatment has been instituted will lead the clinician to search for further pathology.

Essentially, the diagnosis rests with the clinician. It is he who must suspicion the lesion or the roentgenologist may never be given the chance to confirm it. The usual procedure for a patient who presents himself, complaining of loose, frequent stools, is a stool examination. The presence of blood, gross or microscopic, should warrant a proctoscopic examination. Occasionally a rectal polyp is seen, and in some cases, a polyp of the sigmoid can be visualized. If blood seen in the bowel comes from a region beyond the reach of the proctoscope, it is merely a matter of localizing the lesion. It then becomes the problem of the roentgenologist. (None of these cases was uncovered in the ordinary routine gastro-intestinal series in the experience of our department, *i.e.*, any lesion of the large bowel not producing signs or symptoms is too small to be demonstrated by ordinary roentgenologic technic.)

The demonstration of polyps and other small lesions of the bowel is a difficult task. With the development of the double-con-

trast technic, by Weber, of the Mayo Clinic, many lesions otherwise unnoticed have been revealed. This technic is institutes proper preparation. A light barium-buttermilk-water solution is then slowly injected. The head of the column

Fig. 1. Case 1. E. W. Compression spot film.

Fig. 2. Case 2. E. D. G. Compression spot film.

dispensable in very small lesions, and those which are not tangible. Since this procedure is lengthy and requires full cooperation from the patient, we have substituted a simple technic which can be carried out during the routine barium enema examination. In six of the seven cases presented, this procedure was sufficient to demonstrate the lesion. In only one case, that of an obese individual with a very small lesion in the descending colon, was it necessary to resort to the double-contrast method.

The routine procedure employed for colon examinations is as follows: A light evening meal is given the day before and this is followed by two ounces of castor oil. No food is given after the castor oil, but water is permissible. The following morning, breakfast is withheld, and the patient is given a two-quart tap-water enema, lying on his back, and gently rolled from side to side. The patient is then given ample time to expel the enema. This is carefully watched to denote any change from a normal convex to a suspicious concave border. This is an important sign, but lasts only momentarily. A small intraluminal defect is soon inundated by the advancing column of barium. This area is then carefully palpated, pressure being applied first with the examining hand to delineate the lesion. Then, by means of a balsa-wood paddle, an even pressure can be applied over the area, and, at the same time, this area of bowel under pressure can be clearly visualized on the fluoroscopic screen. Any small filling defect is then clearly outlined. With the pressure intact, a spot film is taken, since routine roentgenograms taken of a barium-filled bowel are not diagnostic. Case 6 clearly shows the value of the spot film technic (Fig. 6) if one compares the diagnostic spot films taken on the fluoroscopic table with the routine films (Fig. 5) taken of the barium-filled bowel. Case 5 revealed a suspicious area in the 24-hour film (Fig. 4). The

spot film taken during the enema examination sufficiently confirms the impression. Careful scrutiny of the 24-hour film is a

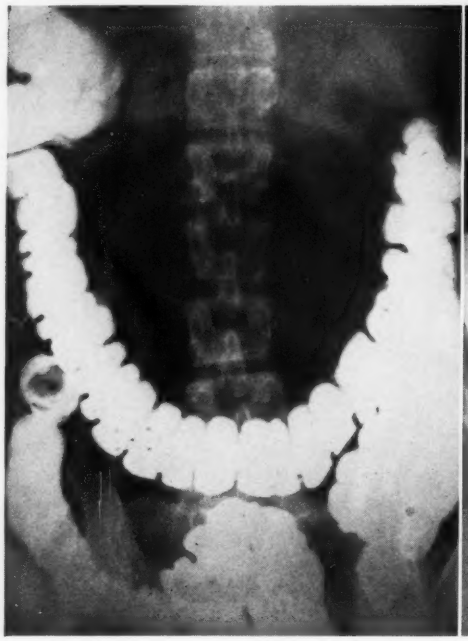

Fig. 3. Case 5. L. E. Routine colon film.

Fig. 4. Case 5. L. E. Twenty-four-hour film.

decided aid in the diagnosis, since it directs suspicion to a certain portion of the bowel which might otherwise be overlooked.

The treatment of polyps is surgical and will not be discussed. The prognosis is excellent even in those cases in which early malignant changes are noted. In those cases presenting gross malignant changes, the prognosis is dubious.

During the past 18 months, seven cases of polyps have been demonstrated by the barium-enema examination. All these cases gave an adequate clinical picture to warrant a diagnosis of an organic bowel lesion. All the polyps were found either in the descending or sigmoid colon. One occurred in a colored male, aged five years, and was a benign adenoma. The other two benign lesions were adenomas occurring in white females in the fourth decade. The remaining four cases showed malignant changes in adenomatous growths. Two occurred in males, one in the fifth and one in the seventh decade. Two occurred in females, one in the fifth and the other in the sixth decade of life.

A brief history of the cases and films of the lesions follows.

Case 1. E. W. Colored male, aged five years. Bloody stools and diarrhea had been present one month; there was no other relevant history. The physical examination was negative. A barium enema revealed an intraluminal shadow at the recto-sigmoid junction. The polyp was removed through a proctoscope. Pathologic diagnosis, benign adenoma.

Case 2. E. D. G. White female, aged 37. The patient was first seen in September, 1937, at which time she complained of loose, frequent stools accompanied by gross blood. Examination elicited tenderness over the descending colon. External and internal hemorrhoids were present. Proctoscopic examination showed blood

coming from a point beyond the region of the proctoscope. The patient entered the hospital in December, 1937, with the same complaint. After complete check-up, including gastro-intestinal x-ray series, she was discharged with diagnosis of irritable colon. The patient continued to have bloody stools. In March, 1938, another barium-enema examination was made. An intraluminal shadow at the junction of the sigmoid and descending colon was demonstrated. Surgical exploration confirmed the diagnosis. The pathologic report was pedunculated adenoma.

Fig. 5. Case 6. G. H. Routine colon film.

Fig. 6. Case 6. G. H. Compression spot film.

Case 3. E. G. White female, aged 32. The patient entered the hospital in July, 1937, with the chief complaint of rectal bleeding. This had been present intermittently for the past year. She was not concerned, however, since she had hemorrhoids. The stools were mushy and varied in number from four to ten a day. She also complained of nausea and pain in the lower left quadrant. Pertinent past history revealed a laparotomy for ovarian cyst and a high fundic amputation in 1929. A right ureteral stricture was dilated in 1931. Physical examination revealed a hard, slightly movable mass in the lower quadrant. There was tenderness in both lower quadrants. The blood cell count (white) was 12,500. The stools were positive for blood and amebæ. The barium-enema examination showed an inflammatory lesion at the junction of the sigmoid and descending colon. The patient was discharged with a diagnosis of amebiasis and given anti-amebic therapy. Six weeks later, she still continued to have diarrhea and bloody stools. Another barium enema was performed and an intralumenal filling defect was found in the descending colon. Subsequent surgical exploration revealed a pedunculated polyp in the colon and a small ovarian cyst with chronically inflamed fallopian tubes. The pathologic

diagnosis was pedunculated adenoma. Cases 2 and 3 well illustrate the fact that persistent symptomatology after apparent negative roentgenologic examination and adequate management, calls for further search for bowel pathology which will lead to gratifying results.

Case 4. J. S. White male, aged 42. The patient noticed gross blood in the stools for three weeks. He had two to three formed stools per day, which he did not believe was unusual. A double-contrast enema revealed an intraluminal shadow. Subsequent surgical exploration revealed a polyp at the junction of the sigmoid and descending colon. Pathologic diagnosis, adenocarcinomatous polyp.

Case 5. L. E. White female, aged 58. The patient entered the hospital for a general check-up, her chief complaint being fatigue, present about one year. She also complained of dizziness, headache, low back pains, dyspnea, and palpitations. Gastro-intestinal examination revealed some nausea the past few weeks, accompanied by slight diarrhea. On direct questioning, she admitted the use of cathartics which provoked two bowel movements daily. Occasionally, she noted blood in the stools. Her past history revealed a pan-hysterectomy 15 years previously. The physical examination revealed a fairly well developed though poorly nourished white female, 58 years of age, not acutely ill. The heart was slightly enlarged and the heart tones were somewhat diminished in volume. The blood pressure was 196/94. An electrocardiogram revealed mild myocardial damage. The blood count and sedimentation rate were within normal limits. The stools showed macroscopic blood. The barium-enema examination revealed an intraluminal filling defect in the descending colon. Surgical exploration revealed a polyp of the descending colon. Pathologic diagnosis, adenomatous polyp with carcinomatous changes.

Case 6. G. H. White female, aged 43. The patient presented herself with a chief complaint of bloody mucus in the stools, for a duration of two weeks. Under careful questioning, she admitted she had had loose stools at intervals during the past three or four years; this was accompanied by marked urgency. The physical examination was negative. A barium-enema examination was made, and a pedunculated filling defect was noted in the sigmoid colon. Subsequent surgical exploration revealed a polyp, removed from the sigmoid colon. Pathologic report, pedunculated glandular carcinoma of the colon.

Case 7. G. D. (?) White male, aged 56. The patient stated that for the past six months he had had frequent loose stools which were accompanied by fresh blood. With each movement there was a cramp-like pain in the epigastrium. Physical examination revealed a white male, aged 56, with marked tenderness in the lower left quadrant immediately below the pelvic brim. The sigmoid colon could definitely be palpated, was movable, and extremely tender. The blood picture was normal. The electrocardiogram revealed moderate myocardial damage. The barium enema revealed a filling defect of the sigmoid colon. Surgical exploration revealed a polyp of the sigmoid colon. Pathologic report, adenocarcinomatous polyp of the large bowel.

SUMMARY

1. The types of polyps most frequently found are adenomas and inflammatory hyperplasia.

2. Polyps are found more frequently in males.

3. Polyps are found most frequently in patients past the age of 40.

4. The distribution of polyps is almost uniform throughout the large bowel.

5. Polyps are frequent precursors of carcinoma.

6. The symptoms of polyps are varied. However, bleeding (all seven patients reported showed blood in the stools) and loose stools are usually present at some time during the clinical course.

7. An adjunctive procedure to the barium enema is described, which is an

aid in the diagnosis of elusive bowel lesions, especially polyps.

8. Seven cases of polyps of the large bowel are presented, along with roentgenographs taken by the author's method.

CONCLUSION

It is expedient to do careful and repeated barium-enema examinations, in those cases presenting symptoms of bowel pathology, in order to diagnose the precancerous and early cancerous lesions.

DISCUSSION OF SYMPOSIUM ON GASTRO-INTESTINAL DISEASES

LEO HENRY GARLAND, M.D. (San Francisco): We have just listened to four interesting and exceptionally well illustrated papers, two on "mucosal technic," one on gall-bladder technic, and one on polypoid lesions of the large bowel. I shall attempt to discuss briefly these four papers with major attention to the first two.

The value of compression technic, especially in disclosing lesions about the pylorus, is now thoroughly established. Its use is greatly facilitated by the rapid radiographic switch emphasized by Dr. Swenson and Dr. Bell, and the latter is to be complimented upon reminding us that a switch of this type can be constructed at no great cost.

It is to be stressed that compression films showing mucosal detail are often difficult to interpret. This applies especially to apparent thickening of the mucosal folds and apparent polypoid changes.

The following case is a good illustration of the latter point: The patient was a female aged 48, a physician's wife who had been complaining of indigestion, occasional slight hematemesis, and slight loss of weight. In January, 1936 (Fig. 1), roentgen examination disclosed a small polyp-like lesion in the gastric antrum. No pedicle could be demonstrated; no mass was palpable; there was only slight localized tenderness.

Films disclosed two tiny additional polyps almost at the pylorus itself. We were naturally disturbed by the possibility of malignant adenoma, but the patient refused exploratory operation and was placed on a high caloric diet. Either as a result of this diet or because of rearrangement of her private life, she gained about thirty pounds in weight and became relieved of all her symptoms.

Roentgen examination in May, 1936 (Fig. 2), disclosed no polyp-like lesion whatsoever.

Now, at the original examination these lesions were visible in all of several films and the large one could be seen under the fluoroscope. They were present on different days and could hardly be due to mucus or food débris. They illustrate one of the additional unsolved diagnostic problems presented by compression technic.

Both Dr. Swenson and Dr. Bell have emphasized that compression technic must be used only as an adjunct to the routine gastro-intestinal examination, and that films of the well filled stomach are always advisable. In spite of the greatest care, one will, of course, make errors even with the combined technics. This applies especially to cases of diffuse gastric infiltration of slow development, especially to cases of linitis plastica carcinomatosa.

In connection with the routine use of compression technic in a busy office or department, I would like to know if Dr. Bell or Dr. Swenson has made measurements as to the amount of scattered radiation received by the radiologist.

Further, I would like to know their opinion concerning the wisdom of recommending nation-wide adoption of a standard barium-water meal (of thin composition—such as barium 4 ounces, water 8 ounces).

Concerning Dr. Ettinger's paper on the upright position in gall-bladder examinations, I can subscribe to the usefulness of this projection. Indeed, ever since reading Dr. Åkerlund's excellent paper in *Acta Radiologica* some years ago we have used this consistently in addition to the ordinary prone views. We believe it is chiefly of value at the "before fat meal" examination for the demonstration of "layer" stones.

Concerning Dr. Jenkinson's paper on polyps of the large bowel, it is to be noted that he referred to cases of solitary polyp and not of multiple polyposis of the colon. In the case of solitary polyp in which there have been symptoms of fairly marked obstruction or fairly marked bleeding, I am sure that Dr. Jenkinson would not recommend the use of castor oil in preparation for the roentgen examination.

In one case in which we suspected a possible solitary polyp in the transverse colon (about 3 cm. in diameter) and used castor oil, we precipitated an acute intestinal obstruction. At operation the lesion turned out to be a large solitary lipoma with a fairly long pedicle. The preparation of these partly obstructive or bleeding cases is quite a problem. Milder laxatives, such as milk of magnesia and gentle cleansing enemas, may have to suffice in some cases.

Fortunately, large solitary polyps do not occur very frequently in the lower sigmoid or rectum. If they are suspected, one should not fail to make a lateral projection, especially following evacuation of the barium. Indeed, in unusually low lesions it may be invaluable to remember that we are physicians and to insert a gloved finger into the rectum at the time of examination.

SAMUEL BROWN, M.D. (Cincinnati, Ohio): I have no argument against the compression technic, believing as I do that at times it may possibly help to make a more accurate diagnosis of ulcers of the duodenum. However, personally, I prefer to demonstrate the lesion without artificial deformities which are bound to be produced when compression is used. Furthermore, compression cannot be used when the lesion involves the fundus of the stomach, or when the duodenal bulb is behind the pylorus. My experience has taught me that a lesion of the stomach or duodenum may be demonstrated provided the area is placed tangential to the x-ray. For this purpose, I have made full use of oblique and lateral views which enable the diagnosis of even minute ulcers.

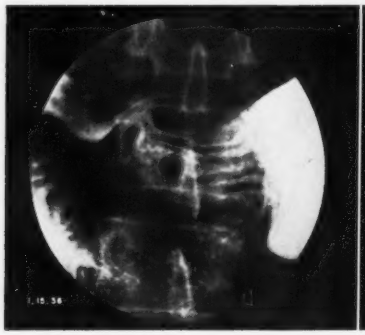

Fig. 1.

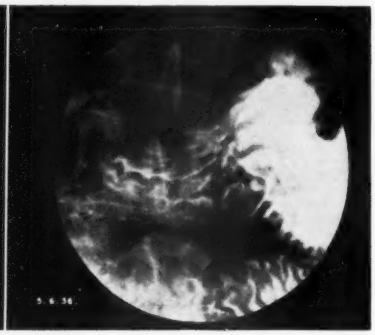

Fig. 2.

PAUL SWENSON, M.D. (*closing*): I was much interested in Dr. Brown's remarks because I do not think any of us here—Dr. Bell, myself, or anyone else who has discussed the compression technic—has meant to imply that it is to supplant the other ordinary procedures that are used.

It is true that there are any number of cases in which the thickness of the patient prevents a good compression film; and in those cases the routine films will have to suffice or lateral films and compression technic may be tried. However, if the thickness of the patient prevents good compression it may also prevent good lateral films. Each case becomes an individual problem.

I also was much interested in the stomach films that Dr. Garland showed, for I recently had the opportunity to examine a similar case which showed, at operation, a diffusely infiltrating lesion, apparently with a much thickened wall which later, at necropsy, showed the thickening to be due to a diffusely infiltrating carcinoma in the submucosa. The mucosa was entirely intact and the stomach had shown active peristalsis when observed fluoroscopically.

In my original paper I mentioned something about the Lysholm grid but I did not mention it to-day. Perhaps a word might be said about the use of the Potter-Bucky or Lysholm grid in conjunction with gastro-intestinal work. We, at the Presbyterian Hospital, now take all our films—routine films of the stomach and duodenum—using the Potter-Bucky technic. Moreover, when we first used this compression apparatus of which I showed slides, we tried fitting in a Lysholm grid just behind the apparatus between the cone, which is brought into the field, and the fluoroscopic screen. However, we found that the game was not worth the candle—that doubling the exposure time was not worthwhile considering the type of film one gets with half the exposure, with good coning down and the use of the shutters in front of the fluoroscopic tube.

I think I might leave the discussion of the standard meal to Dr. Bell, but I would like to say one thing: In the type of small intestine studies we are doing now at Presbyterian Hospital (where perhaps 15 or 20 films are made throughout the course of study, watching the barium move through all parts of the bowel from pylorus to cecum), we use only half the amount of barium usually employed in the routine gastro-intestinal study. We are, moreover, using less and less barium for our compression technic and general gastro-intestinal studies as time goes on. At present, we are giving two and a half ounces of barium with three ounces of water for small intestine study.

EDWARD L. JENKINSON, M.D. (*closing*): I enjoyed Dr. Garland's discussion; his remarks are always instructive. I think he is probably right on the term but a couple of these cases were not single but multiple. In the paper that I read here, we mentioned very definitely we were not talking about polyposis universalis.

Regarding castor oil, I think he is perfectly right in cases that are not carefully worked up. If these patients are gone over carefully (and they must be), with no history of obstruction, I think it is safe to give them castor oil.

When you are looking for a lesion the size of some of these polyps, if the bowel is not thoroughly cleansed, and contains fecal matter, it is oftentimes impossible to say whether the lesions or the areas you find are polyps or fecal matter.

A week ago I discussed this with Dr. Bargen, of the Mayo Clinic, regarding the administration of castor oil. Dr. Bargen thinks that the only usefulness castor oil has is for the cleansing of the bowel prior to a gastro-intestinal examination.

It is true that if these patients have symptoms of obstruction, trouble is apt to ensue, but if a careful history is taken, I think it is more important to find these small lesions for the patient. The possibility of an obstruction occurring following castor oil or the exciting of some inflammatory process or causing the polyp to break off and result in a hemorrhage is not as dangerous as the failure to discover these lesions. Unless the bowel is thoroughly cleansed and properly prepared, most of these lesions will be overlooked.

JOSEPH C. BELL, M.D. (*closing*): In answer to Dr. Brown's remarks, I should like to state again, as I have previously done in my paper, that this method of examination should not be considered as supplanting the conventional methods but simply as an adjunct to the usual type of examination. This is important, for in some cases lesions can be shown most satisfactorily in spot films while in others they may not be but may be demonstrated readily in the conventional manner.

Dr. Brown spoke of some radiologists basing a diagnosis on changes seen in a postero-anterior film. Personally, I feel that this is one of the least valuable films made and I seldom use it, and then only when supplemented by others made in various positions, including the oblique.

In answer to the question concerning the opaque material used in my examinations, I employ a water-barium suspension, using approximately five ounces of each. I learned of this preparation through Dr. Lewis Gregory Cole, about nine years ago, and have used it routinely in examinations of the upper gastro-intestinal tract since that time. I was impressed with the frequency with which his films showed a well filled duodenal cap and suspected that the type of opaque material used might have some relationship to the satisfactory filling. After adopting this preparation, I found that the time required for a satisfactory fluoroscopic examination of the stomach and duodenum was much shorter than when a suspension in buttermilk was employed. This was due to the fact that with the water-barium suspension the opaque material usually passed from the stomach into the duodenum very promptly and permitted a satisfactory examination to be made. Because of the rapid emptying, it was generally possible to secure films showing a well filled duodenal cap.

As to the time required for spot film work, I would say that my examination time is not increased by more than a minute and a half over that used in the ordinary type of examination. There are occasions when it is greater but this is certainly not true in the average case.

Concerning the radiation to which the examiner is subjected, I can only say that I do not know whether or not this will prove to be a serious consideration. I doubt if such will be the case, however, for the area of exposure is very small, the rays first must pass entirely through the patient, then through the cassette, next through the steel cassette carrying pan, and then through the lead glass covering of the fluoroscopic screen. If there is any question about protection, however, one can readily place a sheet of lead one-eighth or one-sixteenth inch in thickness in the metal pan that carries the cassette and this will certainly insure adequate protection. The tunnel itself is lined with one-eighth inch of lead except for the opening through which the fluoroscopic examination is done and the films are made.

Dr. Ettinger presented a case in which the gall-bladder shadow was shown only after the fatty meal. I should like to ask her whether it is not much more likely that the gall bladder was obscured by the shadow of the spine in the first films than that filling and concentration took place only after the fatty meal.

ALICE ETTINGER, M.D. (*closing*): The sedimentation of the layers takes place almost immediately. The time required for the preparation of snapping the film is sufficient to see the effect of the upright position.

As to Dr. Bell's question, I have carefully looked over several films, including the region of the spine, and I could not discover a shadow. Maybe it was too faint; at any rate, it was not visualized in any place overlying the spine.

SIMPLIFIED PLANIGRAPHY[1]

By DIGBY WHEELER, M.A., M.D., C.M., M.R.C.S. (Eng.), L.R.C.P. (Lond.), F.F.R. (Lond.), F.A.C.R., *and* E. W. SPENCER, M.D., *St. Boniface, Manitoba, Canada*

TWINING (5) has developed an attachment for a Potter-Bucky table by which a selected plane or stratum of a patient's body can be shown on an x-ray film. He has also suggested a second attachment; our apparatus, described in this paper, is a modification of this.

This definition of a specified stratum of a body has been given names of "planigraphy," "stratigraphy," and "tomography," and the process is accomplished by moving the tube and the film during the exposure in such a manner that the images of all objects in the selected plane occupy the same position on the film, while the images of all objects above or below this plane are blurred by movement.

History.—Bocage (3), in 1921, described three methods by which a plane section of a solid object could be obtained roentgenographically. All apparatus developed for

[1] The apparatus described in this paper was exhibited at the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

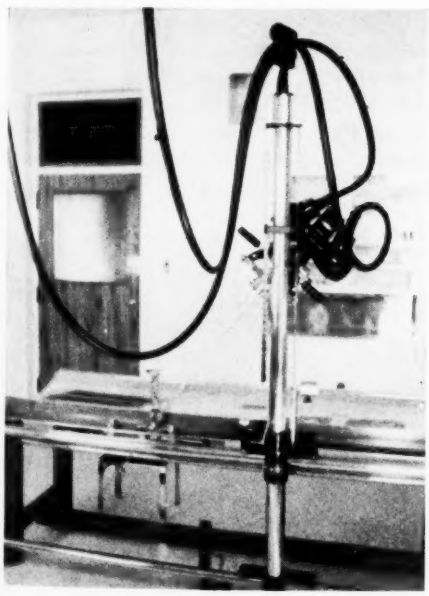

Fig. 1. Bucky table with planigraphic attachment.

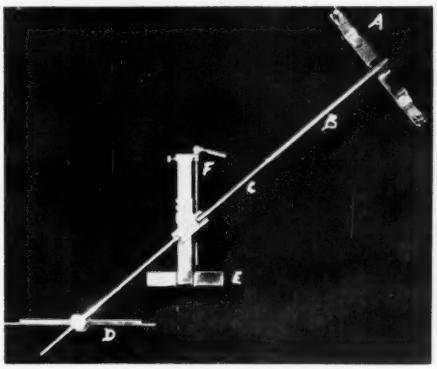

Fig. 2. Planigraphic attachment (parts assembled). *A* is a metal bar which is attached to the tube carrier by wing nuts. Welded to the center of this bar is a metal tube *B*, ten inches in length. *C* is a round metal rod, 48 inches in length, machined to telescope easily but without play, into the tube *B*. The center of this bar is flattened and is connected to *F* by a swivel bolt. *D* is a metal bar attached to the Bucky diaphragm and has a pivot bolt, the exact center of which is at the level of the film which will be placed on the Bucky tray. Vertically, through this pivot bolt is a hole which permits the lower half of *C* to pass without any play. *E* is a right-angled bar of iron bolted to the Bucky table. *F* consists of a sleeve, a screw, and a cap. The sleeve fits down over *E*, and the cap, by means of the thumb screw, becomes rigidly fixed to *E*. It is thus apparent that by manipulating the screw *F* the center of the bar *C* will be raised or lowered and in this way the plane of the body being taken can be varied. A scale is placed on *E* and in this manner the distance of the plane from the film is easily obtained. This apparatus is quickly assembled by attaching *A* to the tube carrier, *E* to the side of the table, passing the lower end of *C* through *D*, placing *F* over *E*. The upper end of *C* is then telescoped into *B*. The height of the axis of *C* above the table top can be read from the scale on *E*. This will form the axis of rotation of the Bucky table system which, in turn, will determine the height above the film of the plane section of the solid object lying on the table. As the tube stand and the tube are moved in one direction the Bucky and the film move in the opposite direction; the tube changes its angle of projection so that the central ray is focussed always on the center of the film.

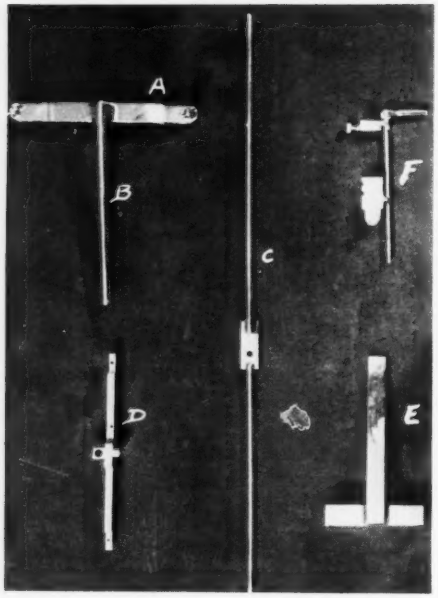

Fig. 3. Planigraphic attachment (parts separate).

this purpose since that date have been based wholly, or in part, on the principles enunciated by him. Jean Kieffer, of Norwich, Connecticut, in 1928, developed his x-ray focussing machine, for which patent was granted, in 1934. Unfortunately, this work was not completed because of illness. Recently, he has announced his "laminagraph." Vallebona (6), in 1930, announced his method and called it "stratigraphy." Ziedses des Plantes (7), in 1932, announced the "tomograph." Siemens and Reiniger, of Germany, are producing the "introscope" commercially. Bocage has developed his "biotome." La Compagnie Générale de Radiologie has announced this year two machines, "Le Stratix" and "L' oscillo-strator." In America, an instrument maker has recently made available his laminagraph.

Considerable work has been done to prove the value of planigraphy as a diagnostic procedure. Andrews (1) and Andrews and Stava (2) have written two very comprehensive papers on the introduction, history, and mathematical proof.

The commercial apparatus listed in the foregoing paragraphs have decided disadvantages, the greatest being the initial cost. Each is an independent unit requiring considerable floor space and being complex of operation.

The apparatus suggested by Twining is a simple, inexpensive attachment. Our apparatus, which is a modification of his, is such as can be made by any machinist. It can be attached to the standard Bucky table in less than five minutes. The central ray in our modification always passes through the center of the film. This is accomplished by a swinging of the tube on its cross-arm axis, as the tube stand moves down the side rail, and the Bucky diaphragm moves up. Figure 1 shows the Bucky table with planigraphic attachment.

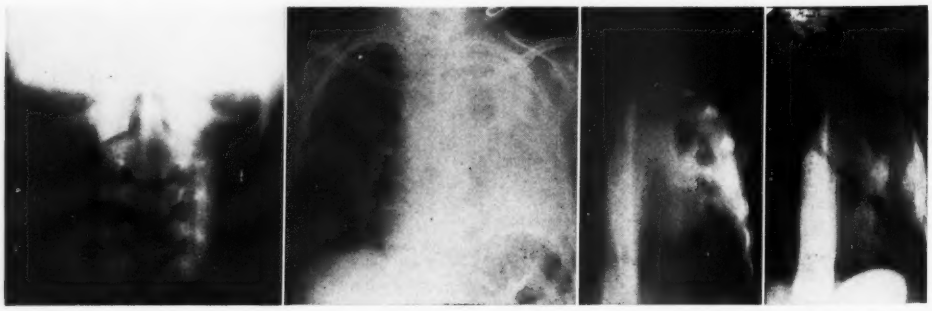

Fig. 4. Fig. 5. Fig. 6.

Fig. 4. Planigraphic section of cervical vertebræ showing dens, mandible, etc., out of focus.
Fig. 5. Postero-anterior view of child's chest showing effusion in left pleural cavity obscuring lung changes.
Fig. 6. Planigraphic studies of same patient as shown in Figure 5, demonstrating cavitation and honeycombing in left upper lobe. Note communication of large cavity with bronchus.

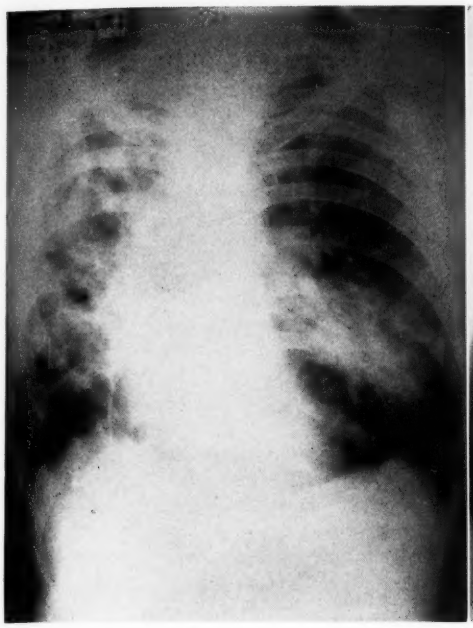

Fig. 7.

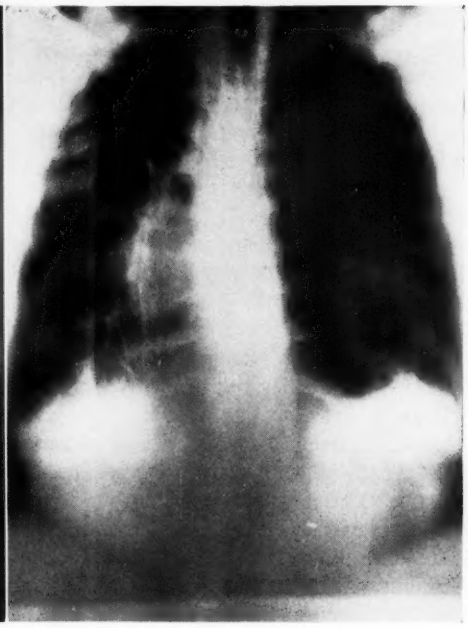

Fig. 8.

Fig. 7. Postero-anterior film of a case of an old chronic chest condition. Diagnosis: extensive fibrosis (?).
Fig. 8. Planigraphic film of the patient shown in Figure 7, showing congenital cystic condition of both lungs.

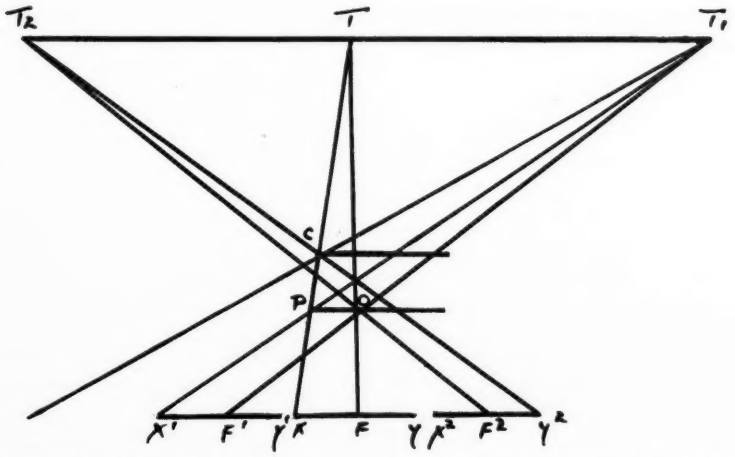

Fig. 9. Mathematical proof of planigraph. T represents the x-ray tube, O the axis of rotation, and XY the x-ray film. During the exposure of the film the tube moves from position T_1 to T_2 and the film moves in the opposite direction from X^1Y^1 to X^2Y^2, the axis of this movement being O. The tube and film move in horizontal and parallel planes and the central ray passes at all times through the axis O to the center point of the film F.

Figures 2 and 3 show the parts assembled and separate.

This apparatus was manufactured at St. Boniface Hospital at very little cost.

When the films are being taken, it is necessary to synchronize the excursion of the tube and Bucky diaphragm with the x-ray exposure. We have contemplated having the tube motor-driven but this would make the apparatus cumbersome and, we feel, would not justify the cost.

Figures 4 through 8 are examples of some of the cases for which this method of diagnosis is used. Its greatest value will be found in the making of chest films and in x-raying those portions of the body obscured by overlying dense structures. The field of applicability may be restricted but it is none the less important. The presence or absence of cavitation is of primary importance in the diagnosis, treatment, and prognosis of pulmonary tuberculosis. The planigraph is justified because of its value in this work alone.

The mathematical proof of the planigraph is shown in Figure 9.

With the system in the vertical position as in ordinary radiography, that is, with the tube at T and the film at XY, the point O on the plane being taken is projected on to the film at its central point F. P on the plane is projected on to the film at X. The point C on a plane above is superimposed on P at X. But with the tube in position T_1, C is projected clear of the film, and with the tube at T_2, C is projected to the opposite end of the film. Thus all points on planes above and below will be blurred because of movement. The points P and O, as well as all other points on the plane being radiographed, will fall on the same points on the film at all times and will thus have clear detail and definition. If this is true, then X^1F^1 must be equal to XF, which is proven as follows:

There are three pairs of similar triangles:

In triangles TFX and TOP,

$$\frac{XF}{PO} = \frac{TF}{TO} \qquad (1)$$

In triangles OFF^1 and OTT_1,

$$\frac{OF \text{ and } TO}{TO} = \frac{F^1O \text{ and } T_1O}{T_1O} \text{ or } \frac{TF}{TO} = \frac{T_1F^1}{T_1O} \qquad (2)$$

In triangles $X^1F^1T_1$ and POT_1

$$\frac{X^1F^1}{PO} = \frac{T_1F^1}{T_1O} \qquad (3)$$

From (1) and (2),

$$\frac{XF}{PO} = \frac{T_1F^1}{T_1O}, \qquad (4)$$

From (3) and (4),

$$\frac{XF}{PO} = \frac{X^1F^1}{PO}$$

$$\therefore XF = X^1F^1.$$

Grossmann (4) lists the following six requirements for successful planigraphy: (1) The effective blurring of large disturbing shadows proximal to the layer to be radiographed; (2) Shortness of exposure; (3) Provision for examining large areas, such as the thorax; (4) Obtaining sharp outline; (5) Variability of the focus–body layer distance, and (6) Simplicity of the apparatus and its operation. Our apparatus, we believe, fulfills all these requirements.

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AMERICAN COLLEGE OF RADIOLOGY ANNOUNCES PROFESSIONAL BUREAU

In 1937 the American College of Radiology started operation of a placement bureau in an effort to bring together those radiologists who were looking for locations and those hospitals and medical groups who were seeking radiologists. This bureau was started as an experimental venture in order to determine whether or not there was need for such a service. During the experimental period very little publicity was given to the availability of such a service but even without publicity the placement bureau has been able to offer its facilities to approximately seventy applicants and institutions. Likewise, it has aided individual radiologists who sought a well trained associate to take care of an expanding practice.

Prior to the establishment of the placement bureau it had been the custom of hospitals to write to a few medical centers which were training radiologists and ask if any well trained man was available. If none was obtainable they were forced to consult one institution after another until a satisfactory man was found. Another source of obtaining radiologists was through the commercial bureaus.

At the recent annual meeting of the Board of Chancellors of the American College of Radiology it was deemed advisable to expand the activities of the placement bureau and make it a truly Professional Bureau. At the present time a full biography including college and medical training, period of internship, and residency, is being compiled for all applicants. Each hospital, or group, or individual requesting a radiologist is asked to furnish detailed information pertaining to the nature of the practice. If a hospital, it is queried concerning size, population of the community, equipment, and other pertinent facts pertaining to its radiological department.

The applicants are requested to state whether or not they are diplomates of the Board of Radiology and to specify their period of training in order that it may be determined whether or not they are to be potential candidates for the Board examinations. The Professional Bureau accepts as applicants only those who have had sufficient training to be candidates for the Board or those who have been awarded certificates by the Board. (The Bureau does not undertake to place residents or to find locations for those men desiring to enter training; nor does it endeavor to furnish technicians.)

At the present time there are eighty-eight approved radiological centers training one or more men. It is the plan that when a request is received, all applicants and the chief of the department in which each man received his training will be notified of the opening. The men are requested to write to the individual or institution for further information and also to furnish the credentials requested. This method of procedure is followed because of the fact that each opening calls for different requirements and by going over the credentials of the applicants the inquirers can select those whom they feel meet their particular needs. The Professional Bureau acts in an advisory capacity between the institution and the applicant and intends to make every attempt to obtain the additional information necessary for each party.

Up to the present time no charge has been made to either applicant or hospital for services rendered. It is evident that the expense to be incurred by the College in the operation of such a Professional Bureau is rather difficult to estimate at the present time, and all expenses are now being borne by the College. It has been decided that if and when the operation of the Bureau is sufficiently large to incur considerable expense from which only the applicants will benefit, then a small registration charge will be made.

All hospitals, groups, clinics, and individuals seeking the service of a radiologist or an assistant in the radiological department are invited to communicate with S. W. Donaldson, M.D., Director of the Professional Bureau, American College of Radiology, 540 North Michigan Avenue, Chicago.

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

Editor's Note.—Will secretaries of societies please cooperate with the Editor by supplying him with information for this section? Please send such information to Leon J. Menville, M.D., 1201 Maison Blanche Bldg., New Orleans, La.

CALIFORNIA

California Medical Association, Section on Radiology.—Chairman, Karl M. Bonoff, M.D., 1930 Wilshire Blvd., Los Angeles; *Secretary,* Carl D. Benninghoven, M.D., 95 S. El Camino Real, San Mateo.

Los Angeles County Medical Association, Radiological Section.—President, M. L. Pindell, M.D.; *Vice-president,* Richard T. Taylor, M.D.; *Secretary,* Wilbur Bailey, M.D., 2007 Wilshire Blvd.; *Treasurer,* Henry Snure, M.D., 1414 South Hope Street; Kenneth Davis, M.D., *Member of Executive Committee.* Meets second Wednesday of each month at County Society Building.

Pacific Roentgen Club.—Chairman, Karl M. Bonoff, M.D., Los Angeles; *Members of Executive Committee,* I. S. Ingber, M.D., A. C. Siefert, M.D., D. R. MacColl, M.D.; *Secretary-Treasurer,* L. Henry Garland, M.D., 450 Sutter St., San Francisco. Executive Committee meets quarterly; Club meets annually during annual session of the California Medical Association.

San Francisco Radiological Society.—Secretary, L. H. Garland, M.D., 450 Sutter Street. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

COLORADO

Denver Radiological Club.—President, N. B. Newcomer, M.D., 306 Republic Bldg.; *Vice-president,* Elizabeth Newcomer, M.D.; *Secretary,* Paul R. Weeks, M.D., 520 Republic Bldg.; *Treasurer,* L. G. Crosby, M.D., 366 Metropolitan Bldg. Meets third Friday of each month at homes of members.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Chairman, Samuel M. Atkins, M.D., 63 Central Ave., Waterbury; *Secretary-Treasurer,* Max Climan, M.D., 242 Trumbull St., Hartford. Meetings twice annually in May and September.

DELAWARE

Affiliated with Philadelphia Roentgen Ray Society.

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Georgia Radiological Society.—President, James J. Clark, M.D., Doctors Bldg., Atlanta; *Vice-president,* L. P. Holmes, M.D., University Hospital, Augusta; *Secretary-Treasurer,* Robert C. Pendergrass, M.D., Prather Clinic, Americus. Meetings twice annually, in November and at the annual meeting of the Medical Association of Georgia in the spring.

ILLINOIS

Chicago Roentgen Society.—President, Roe J. Maier, M.D.; *Vice-president,* Adolph Hartung, M.D.; *Secretary,* Chester J. Challenger, M.D., 3117 Logan Blvd. Meetings the second Thursday of each month from October to May, except December, at the Hotel Sherman.

Illinois Radiological Society.—President, Harry Ackerman, M.D., 321 W. State St., Rockford; *Vice-president,* D. R. Hanley, M.D., St. Mary's Hospital, Streator; *Secretary-Treasurer,* William DeHollander, M.D., St. John's Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—The next meeting will be in Peoria, May 21–23, 1940. The officers are: *Chairman,* Warren W. Furey, M.D., 6844 Oglesby Ave., Chicago; *Secretary,* Harry W. Ackeman, M.D., 321 W. State St., Rockford.

INDIANA

The Indiana Roentgen Society.—President, Juan Rodriguez, M.D., 2902 Fairfield Ave., Fort Wayne; *President-elect,* H. H. Inlow, M.D., Shelbyville; *Vice-president,* Wemple Dodds, M.D., Crawfordsville; *Secretary-Treasurer,* Clifford C. Taylor, M.D., 23 E. Ohio St., Indianapolis. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—President, D. B. Harding, M.D., Lexington; *Vice-president,* I. T. Fugate, M.D., Louisville; *Secretary-Treasurer,* Joseph C. Bell, M.D., 402 Heyburn Bldg., Louisville. Meeting annually in Louisville, third Sunday afternoon in April.

MAINE

See New England Roentgen Ray Society.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Chairman, Harold E. Wright, M.D., 101 W. Read St.; *Secretary,* Walter L. Kilby, M.D., 101 W. Read St. Meetings are held the third Tuesday of each month.

MASSACHUSETTS

See New England Roentgen Ray Society.

MICHIGAN

Detroit X-ray and Radium Society.—President, Sam W. Donaldson, M.D., 326 N. Ingalls St., Ann Arbor; *Vice-president,* Clarence Hufford, M.D., 421 Michigan Ave., Toledo, Ohio; *Secretary-Treasurer,* E. R. Witwer, M.D., Harper Hospital, Detroit. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society club rooms, 4421 Woodward Ave.

Michigan Association of Roentgenologists.—President, J. H. Dempster, M.D., Detroit; *Vice-president,* L. E. Holly, M.D., Muskegon; *Secretary-Treasurer,* J. E. Lofstrom, M.D., 1536 David Whitney Bldg., Detroit. Meetings quarterly by announcement.

MINNESOTA

Minnesota Radiological Society.—President, Leo G. Rigler, M.D., University Hospital, Minneapolis; *Vice-president,* Harry M. Weber, M.D., Mayo Clinic, Rochester; *Secretary,* John P. Medelman, M.D., 572 Lowry Medical Arts Bldg., St. Paul. Meetings quarterly.

MISSOURI

The Kansas City Radiological Society.—President, L. G. Allen, M.D., 907 N. 7th St., Kansas City, Kansas; *Secretary,* Ira H. Lockwood, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Thursday of each month.

The St. Louis Society of Radiologists.—President, Paul C. Schnoebelen, M.D.; *Secretary,* W. K. Mueller, M.D., University Club Bldg. Meets on fourth Wednesday of October, January, March, and May, at a place designated by the president.

NEBRASKA

Nebraska Radiological Society.—President, Roy W. Fouts, M.D., 1007 Medical Arts Bldg., Omaha; *Secretary,* D. Arnold Dowell, M.D., 816 Medical Arts Bldg., Omaha. Meetings third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island.) *President,* Langdon T. Thaxter, M.D., Maine General Hospital, Portland, Maine; *Secretary,* Aubrey O. Hampton, M.D., Massachusetts General Hospital, Boston. Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library.

NEW HAMPSHIRE

See New England Roentgen Ray Society.

NEW JERSEY

Radiological Society of New Jersey.—President, P. S. Avery, M.D., Middlesex Hospital, New Brunswick; *Vice-president,* J. G. Boyes, M.D., 912 Prospect Ave., Plainfield; *Treasurer,* H. A. Vogel, M.D., 1060 E. Jersey St., Elizabeth; *Secretary,* W. James Marquis, M.D., 198 Clinton Ave., Newark; *Counsellor,* A. W. Pigott, M.D., Skillman. Meetings at Atlantic City at time of State Medical Society, and Midwinter in Newark as called by president.

NEW YORK

Associated Radiologists of New York, Inc.—President, I. J. Landsman, M.D., 910 Grand Concourse, New York City; *President-elect,* D. E. Ehrlich, M. D., 35 West 92nd St., New York City; *Vice-president,* Frederic E. Elliott, M.D., 122 76th St., Brooklyn; *Treasurer,* Solomon Fineman, M.D., 133 East 58th St., New York City; *Secretary,* William J. Francis, M.D., 210 Fifth Ave., New York City. Regular meetings the first Monday evening of the month in March, May, October, and December.

Brooklyn Roentgen Ray Society.—President, A. L. L. Bell, M.D., Long Island College, Hospital, Henry, Pacific, and Amity Sts.; *Secretary-Treasurer,* L. J. Taormina, M.D., 1093 Gates Ave. Meetings first Tuesday in each month at place designated by president.

Buffalo Radiological Society.—President, Chester D. Moses, M.D., 333 Linwood Ave.; *Vice-president,* Edward C. Koenig, M.D., 100 High St.; *Secretary-Treasurer,* Joseph S. Gian-Franceschi, M.D., 610 Niagara St. Meetings second Monday evening each month, October to May, inclusive.

Central New York Roentgen Ray Society.—President, Jesse Randolph Pawling, M.D., 305 Clinton St., Watertown; *Vice-president,* Albert Lenz, M.D., 613 State St., Schenectady; *Secretary-Treasurer,* Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse. Meetings are held in January, May, and October, as called by Executive Committee.

Long Island Radiological Society.—President, Samuel G. Schenck, M.D., Brooklyn; *Vice-president,* G. Henry Koiransky, M.D., Long Island City; *Secretary,* Marcus Wiener, M.D., 1430 48th St., Brooklyn, *Treasurer,* Louis Goldfarb, M.D., 608 Ocean Ave., Brooklyn. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—President, Harry M. Imboden, M.D., 30 W. 59th St., New York City; *Vice-president,* Henry K. Taylor, M.D., 667 Madison Ave., New York City; *Secretary,* Roy D. Duckworth, M.D., 170 Maple Ave., White Plains, N. Y.; *Treasurer,* Eric J. Ryan, M.D., St. Luke's Hospital, New York City.

Rochester Roentgen-ray Society.—Chairman, George H. S. Ramsey, M.D., 277 Alexander St.; *Secretary,* S. C. Davidson, M.D., 277 Alexander St. Meetings at convenience of committee.

NORTH CAROLINA

Radiological Society of North Carolina.—President, Robert P. Noble, M.D., 127 W. Hargett St., Raleigh; *Vice-president,* A. L. Daughtridge, M.D., 144 Coast Line St., Rocky Mount; *Secretary-Treasurer,* Major I. Fleming, M.D., 404 Falls Road, Rocky Mount.

Meetings with State meeting in May, and meeting in October.

OHIO

Cleveland Radiological Society.—President, J. H. West, M.D., 10515 Carnegie Ave.; *Vice-president,* Harry Hauser, M.D., City Hospital; *Secretary-Treasurer,* H. A. Mahrer, M.D., 10515 Carnegie Ave. Meetings at 6:30 P.M. at the Mid-day Club, in the Union Commerce Bldg., on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*President,* Archie Fine, M.D., 707 Race St., Cincinnati; *Secretary-Treasurer,* Justin E. McCarthy, M.D., 707 Race St., Cincinnati, Ohio. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—President, Louis A. Milkman, M.D., Medical Arts Bldg., Scranton; *First Vice-president,* James E. Ginter, M.D., Dubois; *Second Vice-president,* Alexander Stewart, M.D., Shippensburg; *Secretary-Treasurer,* L. E. Wurster, M.D., 416 Pine St., Williamsport; *President-elect,* Harvey N. Mawhinney, M.D., 6546 Darlington Road, Pittsburgh; *Editor,* William E. Reiley, M.D., Clearfield; *Assistant Editor,* Sydney J. Hawley, M.D., Danville. Next annual meeting to be held May 17 and 18, 1940, at Hershey Hotel, Hershey, Pa.

The Philadelphia Roentgen Ray Society.—President, Joseph E. Roberts, Jr., M.D., 403 Cooper St., Camden, N. J.; *Vice-president,* Jacob H. Vastine, M.D., Medical Arts Bldg., Philadelphia; *Secretary,* Barton R. Young, M.D., Temple University Hospital, Philadelphia; *Treasurer,* Fay K. Alexander, M.D., Chestnut Hill Hospital, Philadelphia. Meetings held first Thursday of each month at 8:15 P.M., from October to May in Thomson Hall, College of Physicians, 21 S. 22nd St., Philadelphia.

The Pittsburgh Roentgen Society.—President, Zoe A. Johnston, M.D., 601 Jenkins Arcade; *Vice-president,* Prentiss A. Brown, M.D., and *Secretary-Treasurer,* Harold W. Jacox, M.D., 4800 Friendship Ave. Meetings held second Wednesday of each month at 4:30 P.M., from October to June at various hospitals designated by program committee.

RHODE ISLAND

See New England Roentgen Ray Society.

SOUTH CAROLINA

South Carolina X-ray Society.—President, T. A. Pitts, M.D., Columbia; *Secretary-Treasurer,* Malcolm Mosteller, M.D., Columbia Hospital, Columbia. Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

SOUTH DAKOTA

Meets with Minnesota Radiological Society.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—President, Steve W. Coley, M.D., Methodist Hospital, Memphis; *Vice-president,* Eugene Abercrombie, M.D., 305 Medical Arts Bldg., Knoxville; *Secretary-Treasurer,* Franklin B. Bogart, M.D., 311 Medical Bldg., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Texas Radiological Society.—President, C. F. Crain, M.D., Corpus Christi; *President-elect,* M. H. Glover, M.D., Wichita Falls; *First Vice-president,* G. D. Carlson, M.D., Dallas; *Second Vice-president,* P. E. Wigby, M.D., Dallas; *Secretary-Treasurer,* L. W. Baird, M.D., Scott and White Hospital, Temple. Meets annually. The next annual meeting is to be Jan. 18, 1941, in Sherman.

VERMONT

See New England Roentgen Ray Society.

VIRGINIA

Radiological Society of Virginia.—President, Fred M. Hodges, M.D., 100 W. Franklin St., Richmond; *Vice-president,* L. F. Magruder, M.D., Raleigh and College Aves., Norfolk; *Secretary,* V. W. Archer, M.D., University of Virginia Hospital, Charlottesville.

WASHINGTON

Washington State Radiological Society.—President, H. E. Nichols, M.D., Stimson Bldg., Seattle; *Vice-president,* George Cornett, M.D., Yakima; *Secretary-Treasurer,* Kenneth J. Holtz, M.D., American Bank Bldg., Seattle. Meetings fourth Monday of each month at College Club, Seattle.

WISCONSIN

Milwaukee Roentgen Ray Society.—President, H. W. Hefke, M.D.; *Vice-president,* Frederick C. Christensen, M.D.; *Secretary-Treasurer,* Irving I. Cowan, M.D., Mount Sinai Hospital, Milwaukee. Meets monthly on first Friday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, Russel F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

THE COSTS OF RADIOLOGIC EXAMINATIONS

For over forty years, x-rays have been used in the diagnosis and treatment of human ailments. For more than twenty years, roentgenology has been accepted as a specialty in the practice of medicine. The importance of the x-ray in the diagnosis of disease is apparent in any hospital or clinic. In most large hospitals, more patients are examined in the x-ray department than are admitted to the hospital. It is safe to say that about 65 per cent of all patients admitted to a hospital are, at some time during their stay, examined in the x-ray department. At the present time, there are very few physicians who do not use x-rays in their practice. The importance of a careful history and a careful clinical work-up is admitted by all; but to pass judgment on a patient with gastro-intestinal symptoms or a patient with a chest complaint without the assistance of the roentgenologist is, to say the least, not good medicine.

Economically, roentgenology, like all other branches of medicine, is at the crossroads. The Federal Government believes it necessary to build many diagnostic laboratories throughout the country. These laboratories, I have been informed, will be equipped to do all types of diagnostic roentgenology. We might dismiss the idea of the Government's offering all types of medical diagnostic services as a new trend which has entered all walks of business, if it were not for the fact that medical service to the public goes back prior to 1933.

Following the World War, patients, as well as physicians, were demanding more and more laboratory and x-ray work. Due to service-connected ailments, it was necessary for the Government to establish many hospitals throughout the country to care for Veterans. As time passed, the Government became more lenient, probably due to pressure from certain organizations, and it was not long before all types of medical and surgical services were offered Veterans, irrespective of their nature, connection, or duration. It was not uncommon for an employed Veteran to enter a Veteran's Hospital for some surgical operation, such as an appendectomy or herniotomy, or for a gastro-intestinal examination, with no cost to the Veteran. As the Veterans became older, the demands for medical and surgical attention increased. With this increase, the service enlarged, and more and more Veterans were cared for. The operation of these hospitals has undoubtedly served as a stimulus to a generous Government pressed on all sides by powerful organized minorities. In consequence of this pressure and the changing times, the anticipated diagnostic clinics follow. While we all favor the careful, efficient medical care of the needy sick, we likewise feel that free care should be reserved for those unable to pay.

The next step in the efforts to procure more and better medical service at lower cost was the formation of clinics made up of a group of physicians. In this manner, it was possible to delegate certain physicians to do special types of work; in other words, to specialize in a particular field. Five or six physicians could form a clinic made up of a surgeon; an internist; obstetrician and gynecologist; pediatrician; eye, ear, nose, and throat specialist; pathologist, and roentgenologist. With this arrangement, it was possible to give the patients in their community better medical and surgical service at moderate cost. The country contains many large and small clinics which have been successful and have rendered their patients excellent service.

Following the clinic or group practice of medicine, diagnostic clinics were formed at a flat rate. In other words, when a patient visits his physician, it is possible to inform him exactly how much it will cost to hospitalize him, for say a period of four days, including all necessary laboratory and x-ray work. For example: if the patient's income is limited, he can be placed in a ward bed for four days for

$36.00, including all laboratory and diagnostic x-ray work which the physician may deem necessary. A scale of charges is worked out for patients of all income groups; the better the accommodation, the higher the cost. While I feel this is a much needed service, I am convinced it should not include patients able to pay ten dollars a day for a room. I believe the flat-rate diagnostic work-up should be reserved for the low and moderate income groups.

In our experience, the rates arrived at have not been worked out in detail and do not take into consideration actual cost. This applies especially to roentgenology. I feel in some instances that the rates are too low, while in others, much too high.

I could go on and on enumerating many other plans for low cost medical care, such as group hospitalization insurance, over which there has been much controversy. You are all familiar with most of these plans and further comment here would be superfluous.

As roentgenologists, we are not opposed to giving high quality medical service to those in meager circumstances, but I am sure most of us object to being imposed upon by many high-pressure schemes which, after all, deprive the profession of an adequate income.

Most of these plans were formulated by well-meaning men to offer efficient service to the poor patients and those in the low income groups below $1,800.00 per year. Instead of these groups taking the insurance, the higher income groups and large industries have become the recipients of the benefits. The privilege of changing from a ward bed to a private room, and applying the daily allowance granted by the policy against the price of a private room, defeats, I feel, the purpose for which the plan was formulated.

Under some hospitalization plans, a patient in the high income bracket enters a private room, and all diagnostic procedures, both laboratory and x-rays, are done with no additional cost. If the public subscribes to this plan in great numbers, it will not be long before the department of roentgenology, which goes far to cover the expenses of other departments of the hospital, will also be a non-producing department. If this comes to pass, the hospital trustees will hurriedly call in the roentgenologist and inquire why his department is losing money. Consultation with the roentgenologist prior to acceptance of the plan would in many instances have obviated the necessity for the loss.

For a number of years, the average patient has not been satisfied when he visits his physician if only a history is taken or a physical examination made. The public has become educated, and is well aware of the necessity of special examinations by competent physicians, laboratory tests, and x-ray examinations, before an accurate diagnosis can be made. The physician may spend considerable time in taking a complete history and doing a careful physical examination, and as a result feel sure that there is nothing seriously wrong with the patient. Even though the physician assures the patient he is in good health, there is often a feeling of skepticism in the patient's mind, knowing that an early tuberculosis may be overlooked by a physical examination or that certain blood diseases may be present and not be apparent on physical examination.

You might ask, "What has all this to do with the roentgenologist?" First, the patient is demanding more special examinations, which certainly include roentgenology. Second, many physicians hesitate to have all these special examinations made, due to the cost. I know very well that many competent physicians hesitate to have x-ray examinations made because of the cost to the patient. I have talked to many of our own staff members, and they freely admit that often they would like to have a roentgenologic study of the chest made, but, due to the absence of chest symptoms, they hesitate to put the patient to the expense. The same story may be told and retold, especially of patients with indefinite abdominal complaints in which the pathology might be located in the gastro-intestinal or urinary tract.

To obviate many of these causes, the roentgenologist and especially the hospital must co-operate. Only by mutual co-operation can we keep medicine on its high plane. Patients must be able to receive adequate roentgenologic services at a cost they are able to pay.

"The charges should be," to quote Dr. Kirklin, "such that the patient or physician cannot afford *not* to have the examination made."

I do not wish to convey the idea that I am in favor of prices that will necessitate an inferior quality of work. Much has been written in the medical journals recently regarding the cost of films in chest surveys. It is just as fair

to talk of the cost of a scalpel, hemostat, sutures, operating table, special lights, and other instruments in a major operation as it is to mention only the cost of films in a chest or gastro-intestinal examination. A scalpel never cured anyone, but the scalpel in the hands of a competent surgeon has saved many lives. Modern equipment and good quality x-ray films are essential, but after all these have been obtained, a competent roentgenologist is imperative if an accurate diagnosis is to be made.

The average cost per paying patient in our department is $5.03. This may seem high at first thought, but if the figures are broken down, one soon realizes why the cost is high. The average roentgen department does about 25 per cent free work, and when this free work is included in the total expense, the cost per patient greatly increases.

In computing costs per roentgenologic examination, the upkeep of the administrative part of the hospital contributes much to the cost. As you all know, the roentgen department is expected in many institutions to bear the expense of many non-producing departments. Some of the things that contribute to the cost of roentgenologic services are quite evident. First, if the department could be operated like the operating rooms—each operation scheduled and patients taken in turn—I am sure our costs could be reduced. In the roentgen department it is necessary to employ enough assistants to care for the maximum number of patients at all times. Most patients are examined in the forenoon in the average hospital. Physicians often bring the patients in or want to be present when they are examined.

If these patients could be scheduled and taken in turn, the number of assistants and technicians could be greatly reduced and, likewise, the cost. The crowding of the department and the constant demand that "my patient be taken at once" certainly decreases the efficiency of the department and increases the cost.

I have always felt that if the work could be scheduled and divided throughout the entire day, the paid employees could be reduced by 50 per cent.

The most important factor in the increased costs of roentgenologic services is the burden placed on the department by the accepted fact that it must carry some non-profitable departments. Until such time as the hospitals are content to accept a fair return on their investment—say 10 per cent above all expenses plus investment—as a satisfactory income from the roentgen department, prices will remain high. So long as the department is expected to earn enough money to carry several other departments, there is little likelihood of reducing prices to the patients.

I believe the most satisfactory method of dealing with the subject of cost to the patient is the grouping of x-ray charges. The average pay-patient can afford to pay for an isolated x-ray examination, but if his condition is rather obscure and numerous examinations, such as gastro-intestinal, chest, gall bladder, and urinary tract, are necessary, the price becomes high, oftentimes beyond his ability to pay. It is in such instances that much of the adverse criticism of the department develops. I believe every roentgen department should have a group price to offer patients who are required to have numerous and repeated examinations, based on actual cost. For example, if the regular price for doing a gastro-intestinal, gall-bladder, chest, and urinary tract examinations is $60.00, the patient who is required to have all these examinations made should have a substantial discount say, 20 per cent. I am sure such a practice would make the department available to more people and certainly decrease the criticism from our colleagues.

In closing, I must refer to the income of the roentgenologist. You have all heard it said, "The roentgenologist has a monopoly." Weigh the statement, and consider if there is any difference between the roentgenologist and other highly specialized members of the staff; for example, the neurologic surgeon, the endoscopist, the psychiatrist, urologist, surgical services, and many others who enjoy the same so-called monopoly as the roentgenologist. As much money is spent in the development of these departments as is spent for the purchase of x-ray equipment. The hospital charges a fee for the use of operating-room service just as it does for x-ray service, but it does not share in the professional fees of any of the above-mentioned physicians.

In the case of the roentgenologist, the hospital frequently pays him a straight salary and collects all the fees for both diagnostic and therapeutic services. If the arrangement is on a percentage basis, the hospital receives its share of all fees.

Most of the unrest and criticism concerning the monopoly of the roentgenologist emanates

from our colleagues in medicine. The other man's field always looks better and easier; he always seems to get the most with very little effort.

If we will all stop and think, we will come to the realization that few men succeed in any field unless they can deliver, and with this realization will come more unity in medicine, which, I might add, is certainly needed.

E. L. JENKINSON, M.D.

ANNOUNCEMENT

THE AMERICAN SOCIETY OF X-RAY TECHNICIANS

The American Society of X-ray Technicians will hold its fifteenth Annual Meeting at the Peabody Hotel, Memphis, Tenn., May 27 to 31, inclusive.

Many interesting and instructive contributions will be presented at this meeting, on technical subjects, affording the x-ray technicians an opportunity to acquaint themselves with the most modern methods employed in x-ray technic.

COMMUNICATIONS

RED CROSS TO ENROLL MEDICAL TECHNOLOGISTS FOR MILITARY RESERVE

Chairman Norman H. Davis, of the American Red Cross, announced under date of February 20 that at the request of the Surgeon General of the Army and in compliance with its policy of co-operation with both the Army and Navy, the Red Cross, as an expansion of its peace-time service for the military forces, has undertaken the enrollment of various types of medical technologists who are willing to serve in the medical departments of the Army and Navy if and when their services are required at the time of a national emergency.

The plan has been under consideration for almost a year, Chairman Davis said. The enrollment now being inaugurated will be similar to that of the nurses reserve which the Red Cross has maintained for the Army and Navy since 1911, and which is now being expanded to include properly qualified male nurses, and also the reserve of dietitians which has been maintained since 1917.

Persons with the following qualifications will be included:

Chemical Laboratory Technicians (male)
Dietitians (male and female)
Laboratory Technicians (male and female)
Nurses[1] (male)
Occupational Therapy Aides (male and female)
Orthopedic Mechanics (male)
Physical Therapy Technicians—Aides (male and female)
Statistical Clerks (male and female)
X-ray Technicians (male and female).

The Red Cross will work through the various associations and agencies of which these technologists are members, giving to them the details of the plan, including requirements prescribed for enrollment.

In the event of national emergency, the enrolled male technologists who meet the required physical standards will be eligible for enlistment in the Army as non-commissioned officers and in the Naval Reserve as petty officers. Women technologists and men who do not qualify physically, will be eligible for employment by the Army as civilians. Women technologists are not eligible for service in the Navy.

The Navy has indicated that notwithstanding the enrollment with the Red Cross of male technologists eligible for enlistment in the Naval Reserve in emergency, it is desired that in peace-time qualified personnel actually enlist in the U. S. Naval Reserve. The Navy does not require dietitians, occupational therapy aides, or orthopedic mechanics, but all other technologists who may be interested in enlistment in the Naval Reserve are encouraged to communicate with their Naval District Commandant from whom they may obtain full information.

Medical technologists belonging to the groups listed above who are interested, are urged to write National Headquarters, American Red Cross, Washington, D. C., for full information.

[1] This group will not be members of the Army or Navy Nurse Corps., which under basic law is limited to females, but will be used as technologists for service auxiliary thereto.

OWNERSHIP OF THE X-RAY FILM

On June 27, 1939, Mr. G. came to my office suffering with discomfort in one of his feet and

requested me to examine it and advise him what to have done.

After making a physical examination of the foot, I felt that he probably had a spur growing from the under surface of the os calcis, as is frequently seen, and I advised him that an x-ray examination was necessary to be positive of this. The patient agreed with me and we proceeded to make the x-ray examination. Examination of the film disclosed, as we had expected, the presence of a large spur on the under surface of the os calcis in the usual site, which we showed and explained to him.

After some discussion, we advised him to consult an orthopedist for further advice and treatment, which he said he would do.

On leaving the office his bill was presented and he said he would mail us a check for $10.00 from his office.

The next day, Dr. D., an orthopedic surgeon, requested us to send the film to him as Mr. G. had an engagement with him for examination that day. We delivered the film, with our report, to Dr. D. and, as we later learned, Mr. G. consulted Dr. D. and the latter advised operative removal of the bony growth.

On the morning of the second day, we received a registered letter from Mr. G. asking us to send him the film by noon, else he would have no use for it. This letter we, of course, ignored.

During the next several weeks, we tried to collect the bill, but he refused to pay it, stating that he had not gotten the film and would not pay for something he had not received. We entered suit for the amount of our bill, and, at the trial on Feb. 13, 1940, made it plain to the Judge of the Shreveport City Court that we were not so anxious for the $10.00 as for a decision on the point as to whether or not Mr. G. had a right to the film.

Mr. G. argued at length that he owed us nothing as he had not obtained the film. Without much discussion, the Court ruled promptly in our favor and ordered Mr. G. to pay the bill and all costs.

While the highlights concerning the ownership of the film were not played up as prominently as I wished them to be, the decision was against the plaintiff whose sole excuse for not paying the bill was that he had not gotten the film.

This case is reported for what it may be worth in the future, even though the decision was handed down by only a lower court.

S. C. BARROW, M.D.

IN MEMORIAM

WINFIELD G. McDEED, M.D.[1]

DR. WINFIELD G. McDEED, aged 60 years, of Houston, Texas, died Nov. 30, 1939, at Brownsville, Texas, of coronary occlusion.

Dr. McDeed was born Nov. 26, 1879, near Weldon, Illinois, the son of Gordon and Margaretta McDeed. His academic education was received in the schools of his community and at Wesleyan University, Bloomington, Illinois. His medical education was obtained in the Northwestern University Medical School, Chicago, from which he was graduated in 1904. He then practised general medicine in Newton, Illinois, and later in Monticello, Illinois, until July, 1917, when he entered the medical corps of the United States Army during the World War. He was stationed in various midwestern camps prior to a course of study in military roentgenology at Cornell Medical School. During the years 1918–1919 he had charge of the x-ray department at Camp Lee, Virginia. At the conclusion of the war, in which he had attained the rank of captain in the medical corps, he returned to civil practice and located in Houston, Texas, where he practised roentgenology until his death.

Dr. McDeed, after his location in Houston, was a member continuously in good standing of the Harris County Medical Society, State Medical Association, and American Medical Association until his death. He had served as a member of the Board of Directors of the Harris County Dental and Medical Service Bureau. He served the State Association as secretary of the Section on Radiology and Physiotherapy in 1928. He was a member of the Texas Radiological Society, which he had served as president. He was a charter member and former vice-president of the Radiological Society of North America. He was a Fellow of the American Medical Association and a member of the Southern Medical Association. He was chief roentgenologist of St. Joseph's Infirmary of Houston and consulting roentgenologist of Jefferson Davis Hospital, Houston.

He had attained a national reputation in his chosen specialty and was recognized by his colleagues as a radiologist of outstanding ability in both roentgenologic interpretation and treatment.

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[1] Reprinted from the *Texas State Journal of Medicine*, February, 1940.

Dr. McDeed is survived by his wife and three daughters by a former marriage, Mrs. R. W. McFarlin, of Bertram; Mrs. L. D. Rodman, of Normal, Illinois, and Miss Jeanette McDeed, of Canton, Missouri.

Dr. McDeed will be remembered by his many friends in the Radiological Society, who will sorrow to hear of his passing.

BOOK REVIEW

ENDOCRINE GYNECOLOGY. By E. C. HAMBLEN, B.S., M.D., F.A.C.S., Associate Professor of Obstetrics and Gynecology, Duke University School of Medicine, Gynecologist in charge of the Endocrine Division and Sex-endocrine Clinic, Duke University Hospital, Durham, North Carolina. A volume of 453 pages, well illustrated with charts, drawings, tables, and photomicrographs. Published by Charles C. Thomas, Springfield, Ill., and Baltimore, Md., 1939. Price: $3.50.

In this book the author has explained carefully and clearly his wide experiences in this field of medicine. The subject concerns a field that is still in a state of development and about which there continues to exist definite differences of opinion among teachers and investigators. The text is divided into three parts.

The first or introductory portion deals with Sex-endocrine principles. In this there is presented a summary of the development of endocrinology as it is now related to gynecology. The nature of hormones is defined and each principle is described and discussed, together with a list of the preparations that are now available for clinical use.

The second portion of the book is devoted to a discussion of the physiology of these principles as they are related to the three periods in the life of the reproductive or genital apparatus of the human female: (*a*) the period up to the time of establishment of the menstrual function; (*b*) the period of maturity, and (*c*) the period of regression that accompanies and succeeds the climacteric.

The third and last part of the book deals with the pathologic physiology or, as the author terms it, the endocrinopathic gynecology. The minutia of history-taking, physical and laboratory examinations are well stated. In this portion of the book is a chapter on sex-endocrine syndromes in which numerous examples of classical syndromes are presented. Perhaps the impression is conveyed that the physical attributes of a patient, notably obesity and bodily contours, permit the diagnosis of such syndromes. Certainly many patients are seen who have organic disease of the endocrine glands who do not correspond to these classical pictures. In addition, from the standpoint of practical diagnosis and therapy, one should not forget the large number of patients who have evidences of functional disturbances of the anterior lobe of the pituitary and of the ovary who manifest none or very few of the classical pictures presented in this book. Some statements may be challenged as being somewhat all-exclusive, *i.e.*, "childhood obesity should be regarded always as pathologic."

Chapter VII on the Functional Irregularities of Uterine Bleeding is well presented. Excellent reproductions of photomicrographs are used extensively to clarify the author's ideas of diagnosis and treatment. These ideas are very rational on the basis of our present knowledge of the subject and are presented with an intelligent conservatism that may well be heeded.

Chapter IX deals with some of those symptoms and conditions that occur in association with the menstrual function such as dysmenorrhea, headache, vicarious menstruation, allergic symptoms, menstrual edema, menstrual dermatoses, cyclomastrophy (a term that the author prefers to *chronic cystic mastitis*), and menstrual psychoses.

Chapter X is a well rounded out, though brief, discussion of the problem of sterility. This is followed by a short chapter on the Endocrine Aspects of Abnormalities of Gestation. The book closes with a discussion of the Complications of the Climacteric in which the author presents a sound attitude of individualizing the patient's need for treatment and states that those manifesting definite and troublesome symptoms deserve careful treatment with estrogenic substances.

ABSTRACTS OF CURRENT LITERATURE

CONTENTS BY SUBJECT

THE FOLLOWING ABSTRACTORS HAVE CONTRIBUTED TO THIS ISSUE

S. M. ATKINS, M.D., of Waterbury, Conn.
RAY A. CARTER, M.D., of Los Angeles, Calif.
MAX CLIMAN, M.D., of Hartford, Conn.
Q. B. CORAY, M.D., of Salt Lake City, Utah
SYDNEY J. HAWLEY, M.D., of Danville, Penna.
JOHN M. MILES, M.D., of Lafayette, La.
LESTER W. PAUL, M.D., of Madison, Wisc.
ERNST A. POHLE, M.D., Ph.D., of Madison, Wisc.
SIMON POLLACK, M.D., of St. Louis, Mo.
ERNST A. SCHMIDT, M.D., of Denver, Colo.
CHARLES G. SUTHERLAND, M.D., of Rochester, Minn.

ABSTRACTS IN THIS ISSUE LISTED ALPHABETICALLY BY AUTHORS

DEFICIENCY DISEASES

Non-tropical Sprue. A. L. Burgdorf and Thomas A. Barry. Jour. Am. Med. Assn., **112,** 2508, 2509, June 17, 1939.

There appear numerous references in the literature to the sprue syndrome associated with involvement of the duodenum.

The authors reported this case of non-tropical sprue because of the typical exacerbations with the patient on a faulty diet, the repeated remissions with the patient on a hospital regimen for the treatment of sprue, the association with a previously performed gastroenterostomy, the marked loss of stature, and the not unusual negative postmortem observations. The patient was hospitalized four times in a period of five years and three months, and spent seventeen and one-half months in three different hospitals. The records from all these institutions were brought together in the authors' report.

CHARLES G. SUTHERLAND, M.D.

DIABETES

Radiobiologic Observations. G. Dell'Acqua. Strahlentherapie, **65,** 189, 1939.

The author studied the behavior of 17 normal persons and eight with diabetes following x-radiation (200 r) of the pancreatic region and over the upper thigh, by means of Radoslav's test. The latter consists of the study of the sugar curve following injection of from 10 to 20 insulin units. In normal persons the shape of the curve was not influenced either following irradiation of the pancreas nor of the thigh. In patients with diabetes the drop of the curve was more pronounced following exposure of the pancreatic region than after exposure of the thigh. Similar experiments carried out with irradiated insulin did not show any significant changes.

The author also undertook some biochemical studies in patients with leukemia or malignant neoplasms occurring after roentgen therapy. The determinations covered blood sugar, sodium chloride, cholesterin, uric acid, and nitrogen content. Significant was the antagonism between cholesterin and uric acid content: a hypercholesteremia usually was accompanied by a drop in the uric acid percentage.

ERNST A. POHLE, M.D., Ph.D.

DOSAGE

Radiation Doses and Type of Reaction in Fractional Irradiation of Very Small Skin Areas by Means of the Near Distance Treatment Technic. A. Kautzky. Strahlentherapie, **65,** 344, 1939.

When using small skin areas (2 cm.²) and short focal–skin distances (5 cm.), the author noticed that unusually high surface doses were required to produce a definite reaction. The ratio was very high and could not be explained by the difference which is, of course, known to occur when comparing small and large areas. Further investigation of this phenomenon showed that the size of the focal spot of the tube played an important rôle. There is an inner circular area in the field corresponding to the projection of the focal spot, which shows the highest reaction, while the marginal area receives less irradiation.

ERNST A. POHLE, M.D., Ph.D.

Dosimetric Studies of "Tangent" Irradiation. C. Esser. Strahlentherapie, **65,** 500, 1939.

The author compared the distribution of radiant energy in a water phantom for various angles of incident irradiation using a Siemens dosimeter. The technic was: 180 kv., 6 ma., 40 cm. distance, 20 × 24 cm., in two fields, filter equivalent, 0.75 mm. Cu. The results are shown in a series of graphs. It appeared that for tumors lying close to the body surface tangential fields permit the best homogeneous irradiation, at the same time sparing normal tissue in the depth. Depending on the outline of the surface and the size of the tumor, the most suitable angle has to be determined.

ERNST A. POHLE, M.D., Ph.D.

THE EAR

Mastoiditis in Congenitally Deformed Ears. A. T. Wanamaker. Ann. Otol., Rhinol., and Laryngol., **48,** 140–147, March, 1939.

Two cases of mastoiditis in congenitally deformed ears are presented. Pain in the mastoid region in a congenitally deformed ear should call for immediate thorough examination, including roentgenograms. Discharge from such an ear should, likewise, raise the question of trouble in the bone and a probable primary cholesteotoma. Roentgenograms of the two cases are reproduced, together with photographs showing the external deformities.

LESTER W. PAUL, M.D.

FLUORINE POISONING

Chronic Fluorine Poisoning, Seen from the Roentgenological Standpoint. P. Flemming Moller. British Jour. Radiol., **12,** 13–20, January, 1939.

Chronic fluorine poisoning in man was first described by the author, in 1931, as a result of singular findings in the examination of workers in cryolite. The absorption of fluorine takes place almost exclusively from the intestinal tract, there being none through the lungs. The clinical symptoms are nausea, vomiting, loss of appetite, chronic constipation, indefinite rheumatic pains, and stiffness. The principal sign of the disease is the change which takes place in the bones.

In the vertebræ and pelvis, there is almost complete disappearance of the normal structure, the bones becoming very opaque. Occasional trabeculæ, which are thickened and indefinite in outline, will be seen. The outlines of the bodies and processes are indistinct. There is frequent calcification in the ligaments.

The posterior portions of the ribs show long spicules of calcification at the muscle attachments. The pelvis shows the same opacity and numerous calcareous excrescences, pointed or blunt.

The compact layers of the bones of the extremities are much thickened and the marrow cavities narrowed. At the points of attachment of the muscles and tendons there are apt to be large spurs.

In severe cases all the bones will be affected. The degree of involvement increases as the periphery is approached.

The earliest stages show a fleecy thickening with increased whiteness of the bones. The disease gradually progresses through increased thickening, gradual development of ridges and excrescences, to the exceedingly dense final stages. The earliest changes have been observed after two and one-half years of exposure. Slowly growing bone and dental tissues are more susceptible than rapidly growing bone.

Fluorine is commonly found in nature; it is in all volcanic rock. In localities where there is considerable fluorine in the native rock there may be dangerous concentration in the water. Plants can absorb fluorine in toxic quantities, and so may become the source of poisoning of both animals and man. Mining or manufacturing processes involving rocks containing fluorine are the commonest source of poisoning.

Children who are exposed to fluorine in the drinking water or diet are apt to develop mottling of the teeth, which become chalky white with spots of brown or black pigmentation.

S. J. Hawley, M.D.

FOREIGN BODIES

The Late Results of Foreign Bodies Long Retained in the Lower Airways. Ethan F. Butler, N. Stanley Lincoln, John K. Deegan, and Ralph Horton. Ann. Otol., Rhinol., and Laryngol., **48,** 817–838, September, 1939.

The case histories of nine patients having foreign bodies in the lower air passages for long periods of time are presented and analyzed. The longest duration was 16 years, in this instance a wire nail being the offending object. The authors' studies indicate that prolonged residence without concomitant bronchial obstruction or trauma to the lung parenchyma may be well tolerated. If obstruction of a bronchus is present, a suppurative pneumonitis will develop, and, if the patient survives this, bronchiectasis will follow. Acute suppurative pneumonitis has a high mortality and bronchoscopic efforts during this stage are not well tolerated. It is important, therefore, that prompt diagnosis be made with early removal of the foreign body.

Lester W. Paul, M.D.

Simple Radiographic Methods for the Localization of Foreign Bodies James F. Brailsford. British Jour. Radiol., **12,** 65–75, February, 1939.

The numerous methods of localizing foreign bodies reported in the literature indicates that no one of them is entirely satisfactory. The author advises that the physician become familiar with one method, preferably a simple one. The radiographer should follow his cases to the operating room to check his localization and to become familiar with the surgical difficulties encountered. Close co-operation between the surgeon and radiologist is essential. The radiologist should be familiar with the surgical problems; should know what important structures are in the way of removal. The patient should be fixed at the time of operation in the same position as at the time of localization. If possible, he should not be moved at all; lateral and oblique views should be taken by moving the tube rather than the part. Accuracy is more important than speed.

The author suggests the following method as being simple, accurate, and relatively quick. A preliminary anteroposterior film of the area is made, with a marker indicating the wound of entrance. From this film the approximate position of the foreign body can be determined. Markers are placed on the skin, in front and behind, and, if necessary, on each side of the body, approximately over the object. The author uses short pieces of wire bent into different shapes, as they are easily identified and do not obscure the foreign body. Then anteroposterior and lateral films are made. The location of the foreign body can usually be determined by its relation to the markers. The markers are then removed and small scratches made in the skin with a scalpel; these are painted with iodine. These marks will not be obliterated by skin preparation. Due to the cylindrical nature of an extremity, anteroposterior and lateral views will not always give a true picture of the depth of an object from the surface; oblique views are necessary. Screening is not necessary with this method, but it may be used for a rapid preliminary survey. The author does not advocate removal of foreign bodies under fluoroscopic control, because it is dangerous to the surgeon's hands, and because of the danger of inadvertently cutting blood vessels or nerves.

In positions such as the shoulder, hip, etc., a different method must be used. In such situations a marker is placed over the foreign body and a double exposure made, with the tube moved a known distance between the exposures. By triangulation, using the difference in shift of the image of the marker and the object, the depth of the object below the marker can be determined. It is sometimes advisable, in especially thick parts such as the abdomen, to use the double exposure method in both anteroposterior and postero-anterior projections.

In certain cases the injection of sinus tracts will be of aid in locating foreign bodies. The author advises a mixture of bismuth and vaseline. This will not run out of the tract, so that it makes a more satisfactory localization, and its presence will aid the surgeon in finding the object.

It is advisable to locate foreign bodies in relation to prominent bony landmarks whenever possible. If the foreign body is embedded in bone, it will be of great assistance if a needle is pushed through the skin mark in the direction of the central ray until it is embedded in the bone. This will lead the surgeon directly to the foreign body.

The presence of gas in the tissues should always be

looked for in the case of foreign bodies. Frequently the diagnosis of gas gangrene can be made by x-ray examination earlier than by any other method.

SYDNEY J. HAWLEY, M.D.

Nasal Teeth: Report of a Case. L. R. Marshall. Ann. Otol., Rhinol., and Laryngol., **48,** 775–778, September, 1939.

Nasal teeth are not frequently encountered and may give rise to a number of varied signs and symptoms, including localized ulceration. The author reports a case with illustrative roentgenogram. The major symptom was severe epistaxis of nine days' duration. Roentgenograms revealed the shadow of an unerupted cuspid tooth projecting into the left inferior meatus of the nose. After some difficulty, the tooth finally was removed, with complete relief of symptoms.

LESTER W. PAUL, M.D.

FRACTURES

Transverse Fracture of the Petrous Pyramid. William E. Grove. Ann. Otol., Rhinol., and Laryngol., **48,** 491–494, June, 1939.

Fractures of the petrous pyramid may be either longitudinal or transverse. The author reports a case of transverse fracture through the pyramid which was demonstrable by roentgen examination, using Stenvers' position, eight and one-half years after it occurred. Longitudinal fractures are more difficult to demonstrate by roentgenologic examination, even when attempted early, and after the lapse of a month or two such a demonstration becomes practically impossible. The transverse fracture always damages the capsule, and regeneration of bone does not usually occur, due to the peculiar histologic and biologic structure of the bony labyrinthian capsule. These fractures remain roentgenologically visible for many years. The longitudinal fracture is a middle fossa fracture and never involves the capsule directly, hence bony union is to be expected.

LESTER W. PAUL, M.D.

The Closed Operation for Intracapsular Fracture of the Neck of the Femur: Final Results in Recent and Old Cases. Thomas King. British Jour., Surg., **26,** 721–748, April, 1939.

This report is divided into two parts, the first of which is concerned with recent fractures, and the second with old fractures. Lateral, basal, or trochanteric fractures are excluded.

A review of 50 consecutive cases of recent fractures under three weeks old revealed osseous union, by x-ray examination, in 74 per cent of the cases and nonunion in 6 per cent. Some of the remaining cases resulted in death, and in some the final result was unknown.

Degenerative changes in the head of the femur causing osteo-arthritis occurred in 28 per cent of the cases. Osseous union may not be complete in even from three to six months and until this occurs the nutrition of the head of the femur is defective. It is complete only when trabeculations cross the old fracture site. This occurs first in the lower part of the neck but in the upper part there is a tendency for the fracture to separate. Weight-bearing is never permitted under three or four months and often only after six months.

Thirty cases of ununited fracture three weeks or more old are reviewed in this article. In 14 cases of united fracture treated with Smith-Petersen nail, osseous union was obtained in 64 per cent of the cases and almost half of these developed a severe form of osteoarthritis.

In 16 cases of fracture up to two years old, 68 per cent had osseous union and one-third developed osteoarthritis. Patients in poor general condition were not treated by operation. The following conditions should be considered before extra-articular osteosynthesis is justified:

(1) Good general condition of the patient.

(2) Reduction must be obtained and lateral x-ray examination is essential because the neck often lies in front of the head.

(3) The caput femoris must be visible. The head can be considered avascular when x-ray appearance shows a relative density compared with the neck fragment and pelvic bones.

(4) The neck must not be too short, due to absorption, and about one inch at least must remain.

MAX CLIMAN, M.D.

Traumatic Fracture of Pelvis and Wrist, Complicated by Osteitis Deformans (Paget's Disease). Herman H. Huber and Aaron Yaffe. Wisconsin Med. Jour., **38,** 541–544, July, 1939.

The authors report a case of Paget's disease with pathologic fractures of the wrist and pelvis. The diagnosis of Paget's disease was established only when roentgenographs were made for the determination of the presence of fracture. These revealed the typical changes of osteitis deformans including the "cotton-wool" appearance of the skull. The fractures united without delay. Reproductions of five roentgenographs are included.

LESTER W. PAUL, M.D.

GALL BLADDER (NORMAL AND PATHOLOGIC)

Cholecystography in its Fifteenth Year. B. R. Kirklin. Southern Med. Jour., **32,** 822–824, August, 1939.

Cholecystographic interpretation has become more accurate and more conservative through the years and is now as reliable by the oral as by the intravenous method. Scrupulous attention to details and proper technic are important. Homogeneity and change in size and density are the normal characteristics of the visualized gall bladder. Absence, faintness, and mottling of the shadow are the chief marks of abnormality.

With proper technic and sound interpretation, more than 90 per cent of all cholecystographic diagnoses are

correct. Gallstones can be diagnosed in about 70 per cent of cases. Benign tumors and calcification of the gall-bladder wall can be identified as such.

The present limitations of the examination are that, despite the presence of disease, the gall bladder may be represented by a normal shadow and, when the examination does reveal impairment of function, the examination cannot specifically predict the character, severity, or significance of the diseased condition.

JOHN M. MILES, M.D.

Gall-bladder Disease in Patients under Thirty Years of Age. Carl Bearse. Jour. Am. Med. Assn., **112,** 1923–1925, May 13, 1939.

In 300 consecutive cholecystectomies, 63 (21 per cent) patients were under 30 years of age.

Five of these patients had had symptoms for five years or more and one had had symptoms for twelve years.

Fifty-nine of this group (93.6 per cent) had chronic cholecystitis, while only four (6.3 per cent) had acute cholecystitis. Gallstones were found in 41 cases (65 per cent); three of the four patients with acute cholecystitis had gallstones.

Three patients had stones in the common duct.

Follow-up was carried out in 57 (90.4 per cent) of cases in this series. Fifty-three were free of symptoms; 36 of the 37 patients with cholelithiasis were entirely relieved; 17 of 20 with non-calculous cholecystitis were either greatly improved or completely relieved.

CHARLES G. SUTHERLAND, M.D.

GENITO-URINARY TRACT (DIAGNOSIS)

Discussion on Radiology of Tumors of the Urinary Tract. Proc. Royal Soc. Med., **32,** 1455–1482, September, 1939.

Dr. W. D. Newcomb: Dr. Newcomb discusses the pathology of the various renal tumors, emphasizing that small benign tumors are frequent and significant only by their potential malignancy. He discusses the pathologic characteristics of hypernephroma, giving his reasons for considering it to be of renal origin, and contrasts it with the less common solid infiltrative renal carcinoma.

While papilloma of the bladder frequently becomes malignant, the author believes that its tendency to ready implantation is not necessarily a sign of malignancy.

Dr. Rohan Williams: In discussing the radiologic diagnosis of neoplasms of the renal tract, Dr. Williams stresses that excretion urography is not a precision method and should not be used exclusively. The complementary instrumental urography is required to recognize early renal tumors.

Plain roentgenography may reveal local or general neoplastic enlargement of the kidney or its displacement by a large renal cyst or paranephritic tumor. Calcification within a locally bulging renal outline is almost pathognomonic of Gravitz tumor.

Dr. Williams lists the urographic signs of tumor. Combined, these may be characteristic, or may, at times, be bizarre and uninterpretable. A negative pyelogram does not exclude tumor. Dye excretion may fail locally from calices involved by a neoplastic zone, or may fail generally from neoplastic thrombus of the renal vein.

The tumors, usually epithelial, of the bladder are discussed. Calcareous incrustation, occasionally shown by the plain film, favors malignancy. Cystoscopy and biopsy usually make cystography superfluous. The latter is useful when there are ureteral or urethral obstruction, profuse bleeding, or massive tumor. A low sodium iodide concentration (from 3 to 5 per cent) is preferable and double contrast study in useful. The usual trigonal location of vesical tumors requires a special basal projection. The form and location of the tumor are the important factors to learn, since most tumors of the bladder are at least potentially cancerous.

Papillomatous tumors give local crenated marginal defects; the capacity of the bladder is otherwise normal, but its evacuation is seldom complete. Infiltrative carcinoma gives local marginal defects, generally small. The capacity is usually reduced, but evacuation is complete, except when the vesical neck is obstructed.

In the radiological diagnosis, trabeculations of the bladder, extrinsic pressures, non-opaque calculi, and the rarely observed ureterocele must be differentiated.

RAY A. CARTER, M.D.

Roentgen Findings in So-called Urethral Cavernoma. Bo Stenström. Acta Radiol., **20,** 16–21, February, 1939.

The case of a 25-year-old male patient is described, in whom urethral bleeding suggested tumor invasion of the genito-urinary canal. By urethrography (thorotrast), a deformity of outlines in the distal portion of the urethra was discovered. As shown by urethroscopy, this deformity was due to varicose blood vessels. The treatment consisted of coagulation. Roentgenologically and clinically in the differential diagnosis in these cases chronic urethritis, polyps, carcinoma, and urethral infiltrations, as described in leukemia, must be considered.

ERNST A. SCHMIDT, M.D.

GOITER

The Treatment of Severe Thyrotoxicosis. W. O. Thompson, S. G. Taylor, R. W. McNealy, and K. A. Meyer. Western Jour. Surg., Gynec., and Obst., **47,** 522–535, September, 1939.

The majority of patients with severe thyrotoxicosis can best be prepared for operation by taking an adequate length of time and using a high caloric (from 4,000 to 5,000 calories) diet to produce a reasonable gain in weight. At the same time, mental and physical rest, improvement of muscle tone, and administration of iodine are carried on as integral parts of the preoperative régime. When it is difficult to get the pa-

tient to eat enough to produce a gain in weight or when the disease is increasing rapidly in severity, or when cardiac decompensation fails to clear up with iodine and digitalis, it is necessary to resort to some other procedure to prepare the patient. These conditions at the present time represent the most important indications for roentgen-ray therapy in toxic goiter. The dose should be varied according to the patient's requirements and should not be given more frequently than once a week. Following each treatment, there occurs a temporary increase in the severity of the disease and if treatments are given too frequently, the reactions following them overlap, precipitating a crisis. It is best first to expose one lobe and then the other until a total of from eight to twelve treatments has been given. Factors used were 200 kv. (constant potential), 10 ma., 50 cm. distance, cone of 7.5 cm., filters of 0.5 mm. Cu and 1 mm. Al. At each treatment 300 r was given.

Five severely complicated cases, well studied over a long pre- and post-operative period, are presented. Four of these were given pre-operative irradiation, all with excellent results, simplifying the surgical problem by materially reducing the operative risk.

SIMON POLLACK, M.D.

GYNECOLOGY AND OBSTETRICS

Cystographic Diagnosis of Placenta Previa. Robert J. Prentiss and Warren W. Tucker. Jour. Iowa St. Med. Soc., **29,** 252–255, June, 1939.

The use of air cystograms is advocated for the roentgenographic diagnosis of placenta previa. Semilateral films have been found useful in addition to the usual anteroposterior exposures, particularly in showing the posterior marginal type of insertion. In a series of 43 patients with last trimester bleeding, 29 did not have placenta previa and its absence was established accurately in 26 (90 per cent). Fourteen actually had placenta previa and of these, 11 were diagnosed by cystograms, an accuracy of 78 per cent.

LESTER W. PAUL, M.D.

Indications for Sterilization by Irradiation. A. Mayer. Strahlentherapie, **65,** 421, 1939.

The author briefly outlines a number of indications which should be observed in advising sterilization by x-rays or radium. He does not advise roentgen sterilization in women under 40 years of age because the climacteric symptoms are too severe. This holds especially true if the ovaries are still in full function. The psychology of the patient also plays an important rôle and symptoms are apt to be less if a woman desires to have the climacterium brought about. Some information can usually be obtained in the family history; if other members of the family went through the climacteric period without severe symptoms one may assume that the same will hold for the patient under consideration. Women with high blood pressure and with endocrine disturbances should not be subjected to roentgen sterilization. Although it has been claimed that epilepsy, migraine, and asthma may be improved by bringing about the climacterium, the author really thinks that their presence is a contra-indication. Whether or not roentgen sterilization is advisable as a curative procedure in osteomalacia has not been definitely established. As far as the method is concerned, the author prefers the use of roentgen rays because this does not require intra-uterine radium application with its danger of infection, atresia of the cervical canal, and possible hydrometra.

ERNST A. POHLE, M.D., Ph.D.

HEART AND VASCULAR SYSTEM

Tracheal and Bronchial Modifications during the Course of Certain Cardiopathies Affecting the Pulmonary Artery. D. Routier and R. Heim de Balsac. British Jour. Radiol., **12,** 150–157, March, 1939.

Because of the close connection between the trachea and the large bronchi and the heart and large blood vessels, cardiac disease often causes distortion of the trachea and bronchi. Enlargement of the left auricle will cause a spreading of the bifurcation. Other cardiac diseases, by increasing the volume of the pulmonary artery, will cause narrowing of the angle at the bifurcation and compression of the bronchi.

The relations of the bronchial and arterial trees are given in detail as well as the alterations produced by pathologic conditions. Three illustrative cases are quoted with bronchographs to show the bronchial displacements.

SYDNEY J. HAWLEY, M.D.

Coarctation of the Aorta: Case Report. E. Robert Schwartz and G. M. Tice. Jour. Kansas Med. Soc., **40,** 330–332, August, 1939.

A case of coarctation of the aorta showing typical roentgenologic signs is reported. The patient was a 23-year-old white male. Roentgen examination of the chest was done because of the clinical finding of hypertension. This examination revealed notching of the inferior borders of the ribs and a small aortic shadow with absence of the aortic knob on the left. Later, physical examination determined the presence of palpable pulsations over the intercostal spaces posteriorly and considerably higher blood pressure readings in the upper over the lower extremities. Symptoms referable to the coarctation were minimal.

LESTER W. PAUL, M.D.

Visualization of the Chambers of the Heart, the Pulmonary Circulation, and the Great Blood Vessels in Man: A Practical Method. George P. Robb and Israel Steinberg. Am. Jour. Roentgenol. and Rad. Ther., **41,** 1–17, January, 1939.

Visualization of the heart and thoracic blood vessels was proven to be a safe and practical procedure. The method consists of the rapid injection of from 25 to 45 c.c. of a 70 per cent solution of diodrast into an arm vein, and the making of roentgenograms when the

chambers of the heart and blood vessels are opaque to the roentgen ray.

Two hundred and thirty-eight injections were made in 127 patients without serious ill effect. In a few instances a thrombophlebitis of no importance developed at the site of injection.

The injection is made in two seconds and the interval between injection and exposure depends upon the region to be visualized. Average intervals can be used for the right side of the heart, for the superior vena cava and right auricle one and one-half seconds after the beginning of the injection, for the right ventricle and pulmonary arterial tree usually three seconds.

The time for the exposure of the left ventricle averages eight seconds, but may be as late as 20 seconds and, therefore, must be determined before injection. This can be done by the cyanide method which will also determine the thoracic aorta time.

The frontal position is used for the study of the pulmonary circulation; the oblique positions for the heart and aorta. This method provides information regarding the anatomy and physiology of the normal and diseased cardiovascular system heretofore unobtainable.

It is possible to determine the site of stenosis or occlusion of the superior vena cava and its tributaries, and the course and extent of the collateral circulation. The vascular nature of the hilum may be demonstrated and these vessels differentiated from adjacent structures. Accurate study of the arterial and venous patterns of the lung can be made.

The internal structure of the living heart has been revealed for the first time, and abnormalities due to disease have been observed. The following structures became visible: the superior vena cava and its tributaries, the four chambers of the heart, the ventricular walls and the interventricular septum, the tricuspid, pulmonic, and aortic valves, the pulmonic and aortic sinuses, the pulmonary artery, and the entire thoracic aorta, including its wall and the branches from the arch.

S. M. Atkins, M.D.

Gastro-enterology in the Practice of Cardiology. Louis F. Bishop, Jr. Jour. Am. Med. Assn., **112,** 33–35, Jan. 7, 1939.

A study of the symptoms reveals that the most frequent gastro-intestinal symptoms encountered in the practice of cardiology are flatulence, anorexia, nausea, vomiting, dysphagia, jaundice, and abdominal pain. Confusion often arises in the interpretation of these symptoms.

A better understanding of this problem can be had by a consideration of the cardiac-gastro-intestinal relation under three main headings: (1) mechanical; (2) chemical, toxic, and infectious, and (3) reflex.

Under the heading of mechanical influence of cardiac abnormalities on the abdominal viscera, among the most obvious are embolic manifestations from a valvular vegetation—mitral or aortic—or from a thrombus on the left side of the heart. Failure of the right side of the heart with attendant venous congestion leads to chronic passive congestion of the abdominal viscera and thus interferes with the function of these organs. In mitral stenosis of long standing the left auricle dilates, pressing on the esophagus, and occasionally gives rise to dysphagia. An aneurysm may disturb the position or function of the other organs by mechanical pressure on the trachea, esophagus, and abdominal viscera.

Conversely, there are a number of intra-abdominal conditions which may have a direct mechanical influence on the function of the heart. There is a considerable discrepancy between clinical and experimental observation on the effect of flatulence on cardiac function. The mechanism is probably reflex rather than mechanical. The same discrepancy between clinical experience and experimental evidence exists in the effect of abdominal distention from causes other than flatulence, such as ascites, abdominal tumors, and pregnancy, on cardiac function.

It is well known that in passive congestion and edema there is a retention of salt in interstitial tissue, with resultant dehydration. Cardiac tissue is particularly sensitive to alterations in hydrogen ion concentration. Long-standing chronic passive congestion of the liver may disturb its function so that a change takes place in the albumin-globulin ratio of the blood. By this means intercellular edema in the gastro-intestinal tract and elsewhere is increased, and disturbances of gastro-intestinal function result.

The number of extra-cardiac diseases which affect the cardiovascular system by some obscure chemical or toxic means is numerous—typhoid fever, acute and chronic dysentery, and chronic diseases of the gall bladder, to mention only a few. The study of the effect of accessory food substances on the heart and of the disorders of the gastro-intestinal tract which prevent or delay absorption of these substances is an open, promising field.

In abdominal conditions with cardiac manifestations the error of regarding acute disease of the gall bladder as coronary occlusion is all too frequently encountered. Other diseases which may be confused with coronary disease are gastric ulcers, acute pancreatitis, mesenteric embolism, acute intestinal obstruction, esophageal spasm, and diverticulitis.

Charles G. Sutherland, M.D.

A Consideration of the Reflex Etiology of Cardiospasm. Ben L. Bryant. Ann. Otol., Rhinol., and Laryngol., **48,** 802–807, September, 1939.

The theories concerning the etiology of cardiospasm are discussed. Particular emphasis is placed upon the importance of lesions at a distant site in producing cardiospasm due to reflex action. This is illustrated by several cases. In one patient severe cardiospasm developed following a fecal impaction and disappeared after relief of the impaction. In another patient the cardiospasm appeared to be reflex from a gastric ulcer.

While he does not believe that all cases of cardiospasm are due to reflex causes, the author does advocate a thorough study for other lesions in cases of this type since cure of the primary lesion will result in cure or prevention of recurrence of the so-called spasm.

LESTER W. PAUL, M.D.

THE HIP JOINT

A Simpler Method of Internal Fixation of Fractures of the Hip. Dudley M. Stewart. Ohio St. Med. Jour., **35,** 380–384, April, 1939.

The author presents a simple, effective method of internal fixation of the fractured femoral neck by using two ordinary carpenter's screws inserted into the subtrochanteric plane under fluoroscopic control. The maneuver is elective, has been done on patients over 80 years of age, and, in the author's hands, yielded over 90 per cent good functional results in a series of 85 cases. The patients are allowed to rest from five to seven days in Russell traction; this allows better approximation of the fragments and gives an opportunity to discover any complicating pulmonary or cardiovascular renal diseases which are often unsuspectedly present in patients of this age group.

Almost any anesthetic may be used, even intravenous anesthesia, but the author prefers light gas oxygen. The patient may remain on a hospital cart or be transferred to an operating table; the only precaution necessary is that the internal rotation of the extremity be maintained. After the patient is on the table, a portable x-ray unit is used to take the preliminary film. This is then used for fluoroscopic check during the operative procedure. Two ordinary carpenter's screws are introduced parallel to one another from the subtrochanteric plane, through the plane of the fracture, and firmly into the head fragment. After the sutures are removed on the tenth day, the patient is allowed up in a wheel chair and in a few more days is instructed in the use of crutches. No weight-bearing is allowed for about six months, or until evidence of bony union is noted. The screws are not removed. No expensive equipment or instruments are necessary since the screws function physiologically and mechanically better than any other internal fixation instrument.

SIMON POLLACK, M.D.

Early Diagnosis of Congenital Dislocation of the Hip. H. A. T. Fairbank. British Med. Jour., **1,** 607, 608, March 25, 1939.

The author begins by stating simply that the earlier a case of congenital dislocation of the hip is diagnosed, the simpler will be the treatment and the more permanent and perfect will be the result.

In diagnosis, one should first be alert to signs noticed by the mother, and an x-ray examination should always be ordered when any such signs are brought to notice. Limping, weakness, and pain with motion are mentioned. Physical examination shows the usual asymmetry of grooves and curves, prominence of one hip, raised trochanter, and limited abduction. Differential diagnosis must be made from pathologic dislocation, congenital mal-development, and coxa vara. Roentgenographic signs are: shelving, diminution in size of head, and outward and upward displacement of the femur.

Q. B. CORAY, M.D.

The Relationship of Acetabular Deformity to Spontaneous Osteo-arthritis of the Hip Joint. John Gilmour. British Jour. Surg., **26,** 700–704, April, 1939.

About 80 per cent of acetabular protrusions developed spontaneous osteo-arthritis in one or both hips at any age. The recognition of adolescent deformities of the acetabulum as a frequent cause of this condition is of considerable importance. The results of a survey of a series of cases established the fact that the deeper the acetabular fossa the greater the tendency for development of osteo-arthritic degeneration. The problem presented herein is to consider how an increase in acetabular depth can operate to the detriment of the normal hip joint mechanism.

The protective fluid mechanism of the hip joint depends on the sucker-like grip of the cotyloid ring cartilage on the femoral head; the capsule of the joint, and the synovial fluid. Increased acetabular depth modifies each of the above-mentioned factors with resulting failure in the function of the cotyloid ring and diminished efficiency of the fluid buffer within the bony part of the joint in like proportion. The capsule is shortened in cases of protrusion and must modify joint mechanism considerably.

The actual development of osteo-arthritic changes appears to be related to the impairment of function, which is due to the deformity itself.

When function is fairly well preserved, changes develop slowly and x-ray examination reveals thinning of joint space; eburnation of acetabular cortex, and the slow formation of marginal osteophytes on the head and acetabulum. When there is greater interference with the joint mechanism, destructive changes occur earlier and the radiographic findings are: (1) thinning of the joint space; (2) marginal osteophytes; (3) ossification of the transverse acetabular ligament; (4) osteosclerosis of subarticular bone with cystic spaces, and (5) deposition of subperiosteal bone on the inner pelvic wall.

In cases of trauma and superimposed infection, roentgenographs will reveal a greater degree of periarticular sclerosis and interlocking of osteophytes between the head and acetabulum.

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